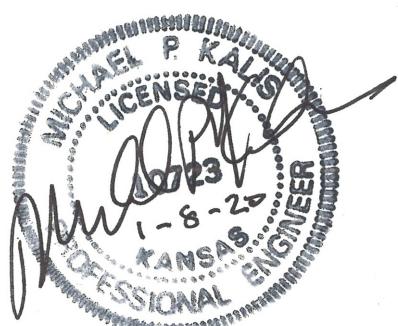




JACOBS



Nelson Complex Biosolids
Facilities - Phase 1 CMSD-
CO28
Basis of Design Report

January 2020

FINAL

JOHNSON COUNTY
KANSAS
Wastewater

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ACRONYMS AND ABBREVIATIONS

AA	Annual Average
ACH	Air Changes per Hour
AHJ	Authority Having Jurisdiction
BFP	Belt Filter Press
BNR	Biological Nutrient Removal
BODR	Basis of Design Report
BRM	Blue River Main
BTU	British Thermal Unit
C1D1	Class 1 Division 1
C1D2	Class 1 Division 2
CHP	Combined Heat and Power
CIP	Capital Improvement Plan
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
DLSMB	Douglas L. Smith Middle Basin
DS	Digested Sludge
EPA	Environmental Protection Agency
FOG	Fats, Oil & Grease
FRP	Fiber Reinforced Plastic
GPD	Gallons per Day
GPM	Gallons per Minute
H ₂ S	Hydrogen Sulfide
HDR/Jacobs	HDR and Jacobs
HPD	Hours per Day
HRT	Hydraulic Retention Time
IBC	International Building Code
JCW	Johnson County Wastewater
KDHE	Kansas Department of Health and Environment
KGS	Kansas Gas Service
L	Liter
LEL	Lower Explosive Limit
LES	Liquid Environmental Solutions

MB	Middle Basin
MGD	Million Gallons per Day
mg/L	Milligrams/liter
MM	Maximum Monthly
MMBTU/d	Maximum Monthly British Thermal Unit/day
MOP	Manual of Practice
NC	Nelson Complex
NCAC	New Century Air Center
NFPA	National Fire Protection Association
NPV	Net Present Value
O&M	Operation and Maintenance
PAD	Post-Aerobic-Digestion
P&I	Principal and Interest
pH	Potential Hydrogen Concentration
Pro2D2	Professional Process Design and Dynamics
ppd	Pounds per Day
RINs	Renewable Identification Numbers
RT	Recuperative Thickening
scfd	Standard Cubic Foot/Day
scfm	Standard Cubic Foot/Minute
SCADA	Supervisory Control and Data Acquisition
SCODLR	Soluble COD Loading Rate
SVSLR	Specific Volatile Solids Loading Rate
Solids Handling Study	Nelson and Middle Basin Treatment Facilities Solids Handling Study
SOP	Standard Operating Procedure
SRT	Solids Retention Time
SUP	Special Use Permit
THP	Thermal Hydrolysis Process
TM	Technical Memorandum
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids

TWAS	Thickened Waste Activated Sludge
UWAS	Unthickened Waste Activated Sludge
UV	Ultraviolet
VA	Volatile Acids
VFA	Volatile Fatty Acids
VFD	Variable Frequency Drive
VS	Volatile Solids
VSLR	Volatile Solids Loading Rate
VSR	Volatile Solids Reduction
VSS	Volatile Suspended Solids
WAS	Waste Activated Sludge
WWTF	Wastewater Treatment Facility

0 Executive Summary

A number of alternatives and optional improvements were analyzed for each design area of the Nelson Biosolids Facilities – Phase 1A Basis of Design report. This Executive Summary reflects the design decisions made as a result of multiple design meetings between HDR/Jacobs and Johnson County Wastewater, since the draft of this Basis of Design Report (BODR) in September 2019.

0.1 TWAS Receiving

Several locations and layouts were evaluated to receive hauled TWAS from the New Century Air and Blue River Main WWTFs. We evaluated the use of the abandoned sludge holding tank by Building 3, but determined its volume was insufficient and access was limited.

- Selected Alternate 4, with the sludge transfer pumps located within Building 12 and hauled sludge receiving stations located in a drive-up area outside the building.
- Sludge hauling trucks will go around the Mission Main loop, then back into the unloading area after turning the corner at Building 4, see Figure 0-1.
- Drivers will utilize the gravel area next to Digester 4 as a staging area if another sludge hauling truck is currently backing up, see Figure 0-1.
- Added isolation walls within Building 12 around the sludge transfer pumps in order to create an unclassified space, with new HVAC providing 6 air changes per hour.
- Included a pipe spool ahead of the transfer pumps for the future installation of grinders if ragging becomes an issue.
- See Figure 0-2 for the TWAS area layout.

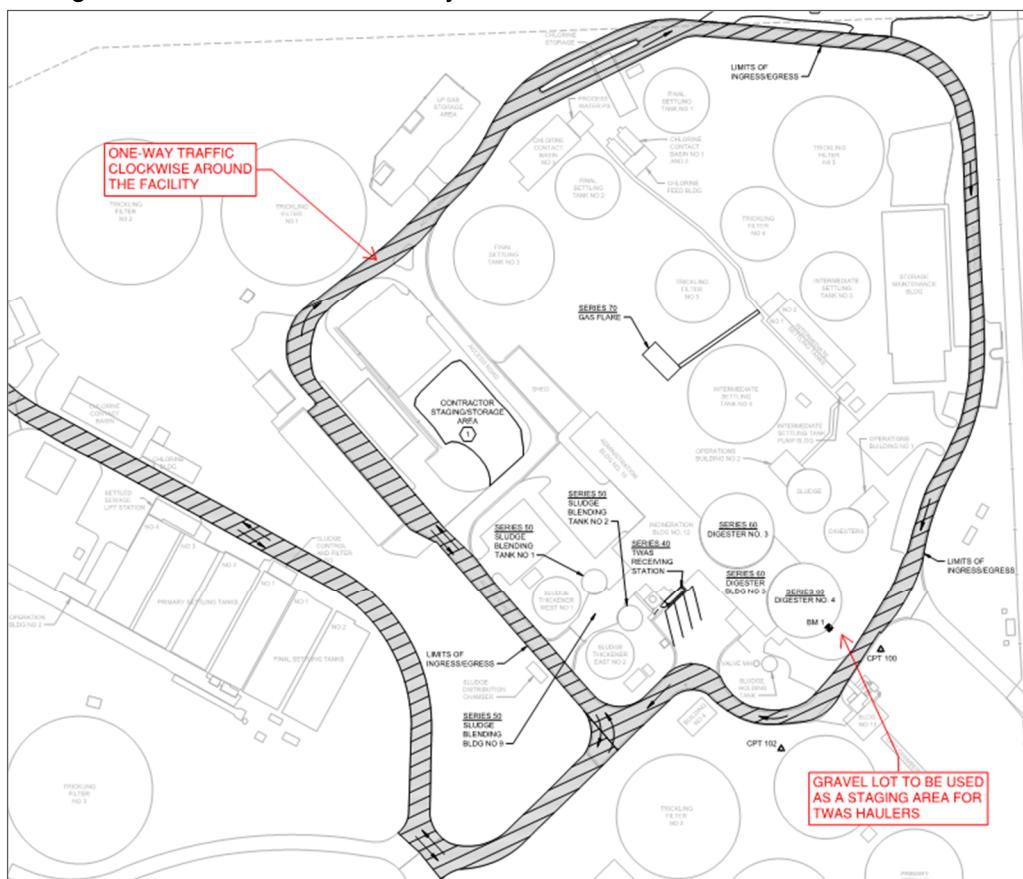


Figure 0-1: Mission Main WWTF Site Layout

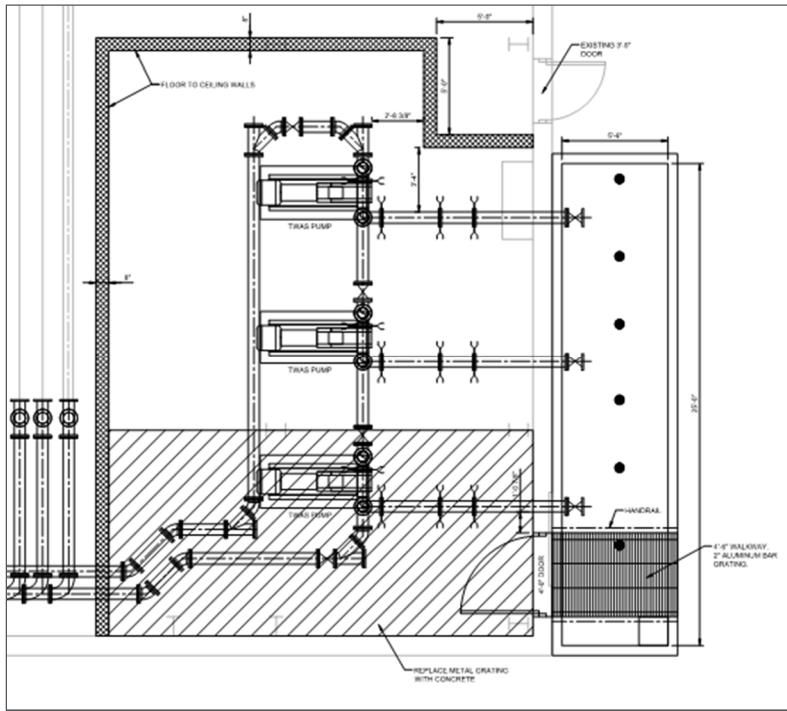


Figure 0-2: TWAS Transfer Pump Room

0.2 Sludge Blending

Hauled TWAS is blended with Nelson Complex sludge prior to being sent to Digester 3. Existing Sludge Holding Tanks 1 and 2 will be converted into Blend Tanks 1 and 2.

- Selected roof mounted mechanical mixing.
- Interior tank improvements including baffles and surface recoating.
- Tank lid improvements including a mixer support pad and new access hatch.

0.3 Building 9 Transfer Pumping

Piping from the new pumps installed in Contract 20 will be rerouted to transfer sludge from the Blend Tanks to Digester 3. Digested sludge is pumped back through Building 9 to Building 14.

- The delaminated pipe and centrifuge feed pumps within Building 9 will remain as is. These items will be replaced in the future in the event of failure.

0.4 Sludge Digester Facility

What are currently Sludge Holding Tanks 3 and 4 will be reconfigured to become Digesters 3 and 4. This will be done through the installation of mixing equipment in Digester 3, new fixed covers, sludge heating loops, waste gas disposal, and various pumping and piping improvements.

- Digester 3 will be a primary digester and Digester 4 will be a secondary digester.
- Equipment layouts will consider the future upgrade to give both Digesters primary digester capabilities and allow easy addition to the configuration.
- New HVAC improvements will provide 12 air changes per hour will be added to the lower level of Building 3 to give it a C1D2 space rating, with the exception of a 5 foot envelope around the digester walls which will remain C1D1.

0.5 Digester Heating Equipment Room

Due to space classification constraints, several alternatives were evaluated for the housing of the digester heating equipment. A new-construction, separate building and several varying declassifications of the upper floor of Building 3 were considered.

- Selected Alternative 4, the installation of isolation walls, for space classification on the upper floor of Building 3.
- Provided 4 feet of clearance around both digesters for plant operator access to other areas.
- An exterior stair tower from the ground level to the roof for egress.
- See Figure 0-3.

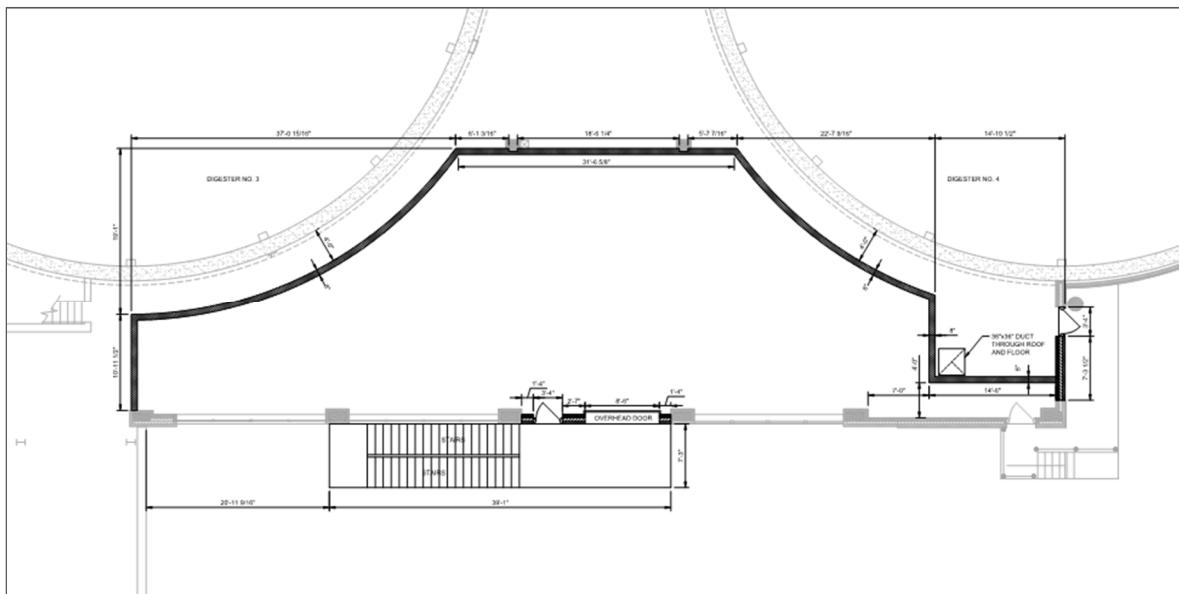


Figure 0-3: Building 3 Upper Floor

0.6 Odor Control Improvements

The odor control scrubber, recirculation pumps, and chemical feed pumps are located in the lower level of Building 3. The scrubber duct extends through to the roof.

- The chemical feed pumps will be replaced.
- The scrubber, recirculation pumps, and duct will remain as is. These items will be replaced as needed in the future in the event of failure.

0.7 Chemical Storage Room

The chemical storage room off the lower level of Building 3 currently houses two sodium hypochlorite storage tanks and one sodium hydroxide storage tank. These existing tanks will all be demolished and a single, 3,000 gallon, double walled hypochlorite storage tank will be installed. New metering pumps and control panels will also be installed.

- The relocation of the Sodium Hypochlorite storage tank and filling receptacle was discussed, due to the infrequency of filling and difficulty locating an accessible location.
- For code compliance, the door to the room will be replaced with a 3-hour fire rated door.
- See Figure 0-4.

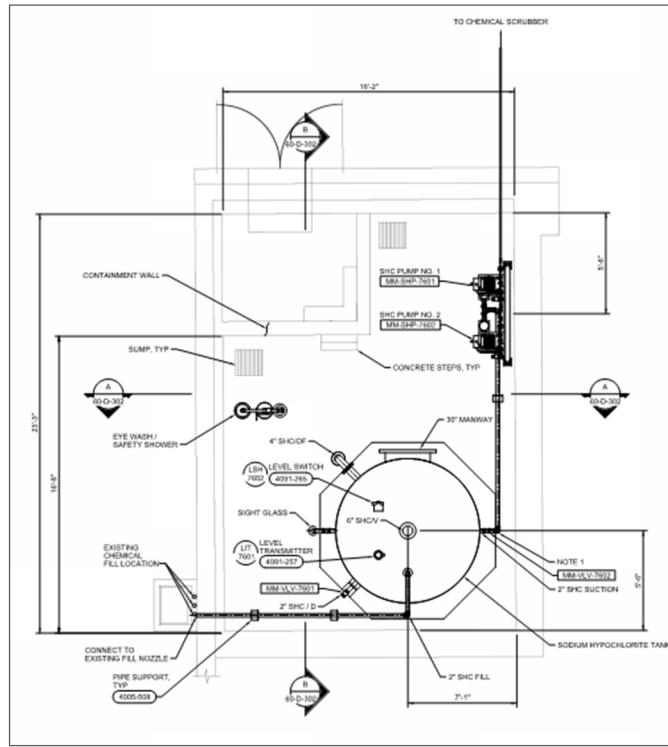


Figure 0-4: Chemical Room

0.8 Waste Gas Flare

All biogas produced by the digesters will be collected and sent to a waste gas flare. Several locations were considered based upon proximity to the digesters, distance to homes, and placement in regards to the future Nelson WWTF sitewide construction project. The installation will consist of one duty and one standby enclosed waste gas flares. Piping to the flare from the digesters will have a mowstrip installed around it to reduce ground keeping maintenance. The piping installed will also include tees in strategic locations for the future relocation of the flare pad.

- Placed near the middle of the plant to reduce noise broadcasted to nearby neighbors.
- This is a temporary location, a more suitable final location will be determined once the future Nelson WWTF rebuild project has reached its final design iteration.
- See Figure 0-5.

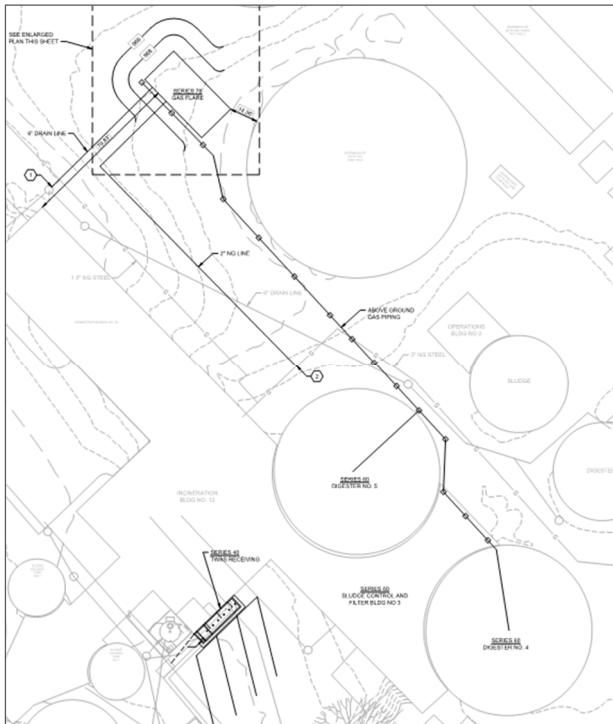


Figure 0-5: Waste Gas Flare

0.9 Cost Estimate – 30% Design

Project Area	Construction Cost
TWAS Receivng	\$455,000
Building 9: Sludge Blending and Transfer Pumping	\$966,000
Building 3: Digester 3 Primary, Digester 4 Secondary, Backup Boiler, Dual Flares, Chemical Storage and Feed Improvements	\$6,175,000
Subtotal Construction Cost:	\$7,596,000
Engineering, Legal, Administration (27.5%):	\$2,089,000
Total Cost:	\$9,685,000

1 General

1.1 Project Description

Johnson County Wastewater (JCW) has retained the consulting team of HDR and Jacobs (HDR/Jacobs) to provide design phase and bidding phase services for the Nelson Biosolids Facilities Project – Phase 1A, Contract CMSD-C028. The purpose of this Basis of Design Report (BODR) is to present the concepts and design criteria that will be the basis of the final design and construction documents for the project.

The project will consist of the following primary components:

- Re-commissioning of a currently empty digester (Digester 3) and conversion of an existing sludge holding tank (Digester 4) into a two-tank, 2 stage digestion process
- Facilities for receiving trucked in Thickened Waste Activated Sludge (TWAS) and blending it with sludge generated at the Nelson Complex prior to feeding to the digesters
- Sludge transfer pumping improvements
- Digester gas flaring
- Rehabilitation of the liquid scrubber odor control system, including the associated chemical storage and feed facilities
- Ventilation and other improvements to improve space classifications and hazardous gas detection upgrades for safety purposes

In addition to discussing the above improvements, this BODR will assess the impact of digestion on the current dewatering operation and will include an opinion of probable cost, a project schedule, and an assessment of permitting requirements.

1.2 Background

Anaerobic digestion was included when the original phases of the Nelson Complex Wastewater Treatment Facility (WWTF) [known as Mission Township Main Sewer District No.1 at that time] were constructed beginning in the 1940's. As the facility grew in stages, four digesters were ultimately constructed; two smaller (Digesters 1 and 2) and two larger (Digesters 3 and 4). Digestion was discontinued in the 1970's, and the digesters were abandoned in place.

In 2015, JCW commissioned CDM Smith to design Nelson Complex Solids Handling Improvements, Contract CMSD-C020. This project, for which construction was completed in 2018, included conversion of abandoned Digester 4 to a sludge storage and mixing tank, gravity thickener improvements, sludge transfer pumping improvements, and improvements to the centrifuge dewatering and polymer systems.

In 2016, JCW commissioned HDR/Jacobs to prepare the Nelson and Middle Basin Treatment Facilities Solids Handling Study (Solids Handling Study). The portion of the study dealing with the Nelson Complex laid out a phased approach for implementing anaerobic digestion. The phasing plan was subsequently modified during the Nelson Complex WWTF Facility Plan (Nelson Facility Plan) in preparation to better align with the scheduled plant-wide biological nutrient removal (BNR) project. The following are phases were identified in the Solids Handling Study and are currently envisioned to be implemented in three steps:

- Phase 1A – Convert existing Digesters 3 and 4 to a two-stage digestion system and associated improvements as discussed in Section 1.1. This initial phase is scheduled for construction in 2020 and 2021. This will provide sufficient digestion capacity for the solids generated at the existing tricking filter facility plus a portion of the hauled TWAS from the Blue River Main (BRM) and New Century Air Center (NCAC) WWTFs.
- Phases 1B, 1C, 2 and 3 – These will all be consolidated into a single effort as part of the larger BNR project. This will include two additional primary digesters, equal in size to the existing Digesters 3 and 4, plus a fats, oils, and grease (FOG) waste receiving facility. It is scheduled for completion in 2028. This will provide sufficient capacity for the increased quantity of biosolids generated by the BNR process, all current and forecasted future hauled TWAS, and a FOG waste receiving facility similar in size to that at Middle Basin, while providing a redundant digester.
- Future – One component included in the original phasing plan, as part of Phase 2, was gas cleaning and utilization for cogeneration. This will be deferred to an unspecified time in the future.

The digester complex will be retained as part of the BNR facility. However, the centrifuge facility, gravity thickeners, TWAS blending tanks, and associated facilities are likely to be demolished and replaced with new facilities as part of the BNR project. The Phase 1A design will include provisions for these future improvements where practical.

2 Process Design

This section of the BODR serves to establish the solids process design basis taking into account recommendations from the Solids Handling Study and the Nelson Facility Plan.

2.1 Existing and Future Biosolids Quantities and Characteristics

Biosolids production estimates were created for current operations of the Nelson Complex as well as for the future configuration identified in the Nelson Facility Plan, which recommended a 5-stage Bardenpho configuration as the representative approach to BNR to meet future effluent discharge requirements.

Current solids production was estimated as part of the Solids Handling Study. The production of solids at the Nelson Complex was estimated separately from hauled TWAS from the New Century Air Center (NCAC) and Blue River Main (BRM) WWTFs that are discharged into the Nelson Complex solids processing system. Solids estimates for the current condition are documented in Workshop No. 1 for the Solids Handling Study.

Solids production estimates from the future BNR WWTF were developed utilizing a calibrated process model developed during the Nelson Facility Plan. The model was developed utilizing Jacob's Professional Process Design and Dynamics (Pro2D2) software. Calibration of the model was documented in the Basis of Analysis Technical Memorandum of the Nelson Facility Plan (April 2018). The model was later modified to represent the recommended future BNR condition and further updated as part of this project.

Table 2-1 represents solids production estimates for current and future conditions. Hauled TWAS and FOG loading estimates were also determined in the 2017 Solids Handling Study. The TWAS estimates included current production from NCAC and BRM and estimates for build out of these two facilities. Under the initial phase (Digestion Phase 1A), the amount of hauled TWAS that can be received at the Nelson Complex is limited to current production estimates so as to maintain production of Class B Biosolids, which requires a minimum hydraulic retention time (HRT) of 15 days. The allowable hauled TWAS for the initial phase was estimated using a hauled TWAS concentration of 4.3% TSS. Hauled TWAS receiving may be increased if further thickening of the sludge from NCAC or BRM can be achieved.

FOG will not be received until future phases of the solids expansion. For future predictions, FOG quantities were limited to the maximum allowable loadings identified in the 2017 Solids Handling Study for both average and maximum month conditions. While an increased FOG load could be received during average WWTF solids production, the allowable FOG load should be re-evaluated as part of the future BNR WWTF design.

Table 2-1: Biosolids Production Estimates

Component	Current WWTFs ¹			Future 5-Stage BNR WWTF ²		
	Average Day	Max Month	Peak 2-Week ³	Average Day	Max Month	Peak 2-Week ³
Thickened Primary Sludge⁴						
Flow, gpd	40,000	52,000	56,000	31,100	41,600	47,400
Mass Load, lbTSS/d	15,000	19,500	21,000	11,700	15,600	17,800
Solids Concentration, %TSS	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
Volatile Solids Fraction, %VS	85%	85%	85%	86%	87%	87%
Nelson TWAS						
Flow, gpd	NA	NA	NA	26,100	36,200	40,900
Mass Load, lbTSS/d	NA	NA	NA	10,900	15,100	17,100
Solids Concentration, %TSS	NA	NA	NA	5.0%	5.0%	5.0%
Volatile Solids Fraction, %VS	NA	NA	NA	70%	73%	73%
Hauled TWAS^{5,6}						
Flow, gpd	55,800	44,700	40,711	55,800	72,500	78,100
Mass Load, lbTSS/d	20,000	16,000	14,600	20,000	26,000	28,000
Solids Concentration, %TSS	4.3%	4.3%	4.3%	4.3%	4.3%	4.3%
Volatile Solids Fraction, %VS	78%	78%	78%	78%	78%	78%
FOG⁷						
Flow, gpd	NA	NA	NA	23,300	23,300	23,300
Mass Load, lbTSS/d	NA	NA	NA	13,600	13,600	13,600
Solids Concentration, %TSS	NA	NA	NA	7.0%	7.0%	7.0%
Volatile Solids Fraction, %VS	NA	NA	NA	87%	87%	87%

¹Current WWTFs Production based on Solids Handling.

²Future BNR WWTF production based on Pro2D² process modeling

³Peak 2-week solids load based on the 1.4 multiplier to average day established in the Solids Handling Study

⁴Thickened primary solids for the current WWTFs include solids from the intermediate and secondary clarifiers

⁵Maximum allowable hauled TWAS in Phase 1A set by minimum digester SRT of 15-days to achieve Class B Biosolids, current average hauled TWAS is approximately 26,900 gpd.

⁶Future hauled TWAS estimated at build out estimates of NCAC and BRM WWTFs.

⁷Future WWTF FOG receiving set to the max allowable during max month solids production estimated in the Solids Handling Study

2.2 Process Flow Diagram

The Process Flow Diagram is depicted in Figure 2-1. A larger image of this can be found in Appendix A3.

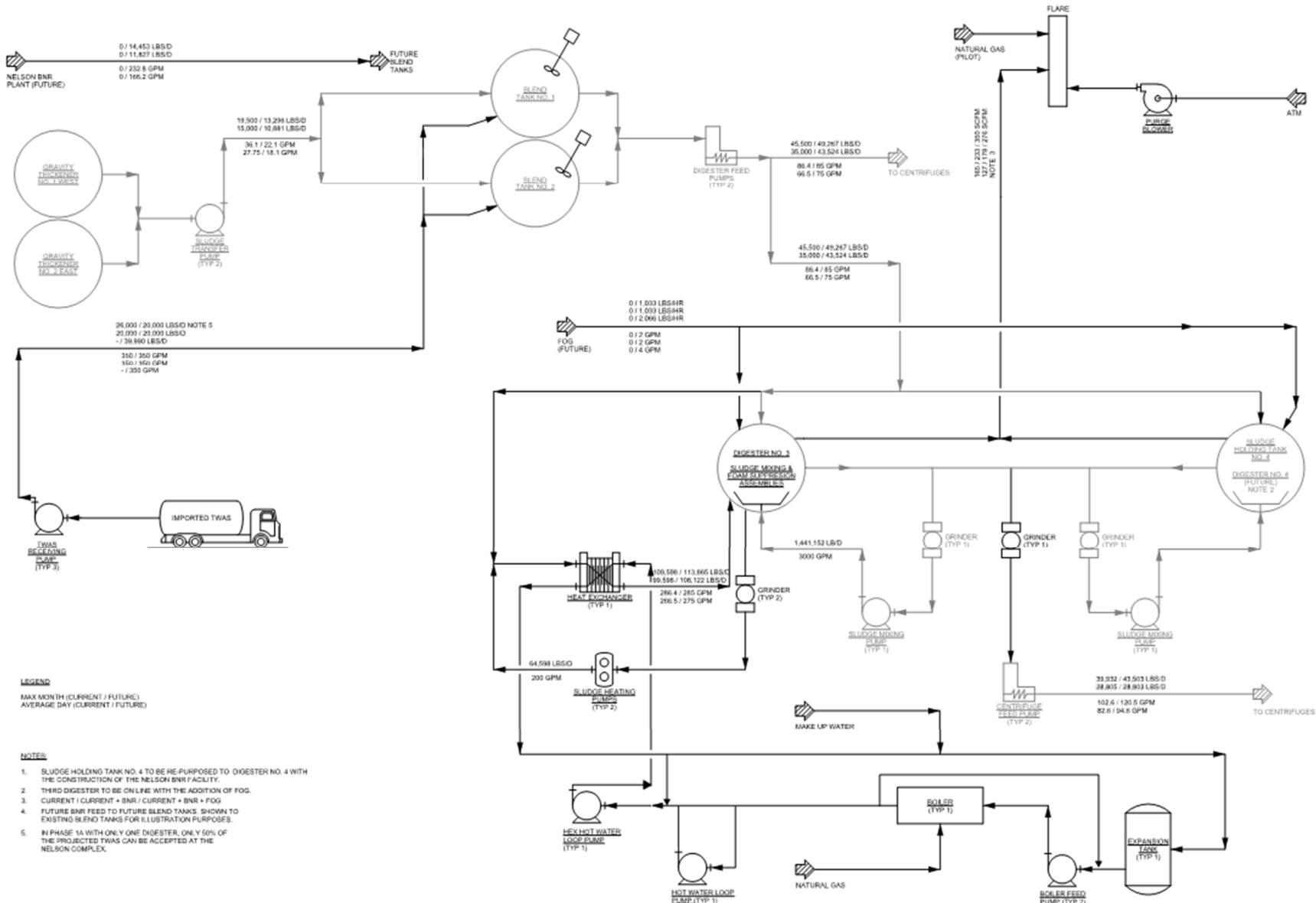


Figure 2-1: Process Flow Diagram

2.3 Design Criteria and Calculations

Mesophilic anaerobic digestion is the primary treatment unit process associated with Phase 1A. This project includes converting the existing Sludge Holding Tanks No. 3 and No. 4 into primary and secondary digesters, Digester No. 3 and Digester No. 4, respectively. In the future, two additional digesters will be added for stabilization of future BNR sludge along with TWAS and FOG.

The supplemental sampling completed as part of model calibration in the 2019 Nelson Facility Plan suggested that the non-biodegradable portion of the influent volatile suspended solids (VSS) could be higher than typical domestic wastewater. That is, a higher portion of the volatile solids could be associated with non-biodegradable organic material such as cellulosic material. While this should be confirmed through additional sampling prior to final design of the BNR facility, this finding will serve as the conservative basis of this Phase 1A design..

Key considerations related to these observations are as follows:

- An elevated influent non-biodegradable VSS component results in a higher aeration basin MLSS concentrations for a given influent load because more of the basin is occupied by non-biodegradable material. As a result, a more conservative estimate of the conceptual sizing required for the future BNR system was developed.
- Conversely, an elevated influent non-biodegradable VSS component yields digester volatile solids reduction (VSR) near 40%, which is lower than the typical 45 to 55% for typical domestic WWTFs.
- The solids loading projected herein considered a range of possible non-biodegradable VSS and resulting VSRs to provide a wider design range to size ancillary solids equipment. The maximum month projections utilized the lower VSR, which resulted in higher solids loading downstream of digestion, whereas average day conditions utilized an increased VSR to provide lower-end design conditions.
- Additional influent sampling and process model refinement is recommended once discharge of hauled TWAS to the Nelson Complex collection system ceases. This sampling and model refinement will provide additional insight into the influent wastewater characteristics, allow for refinement of future BNR facility design as well as provide clarification on solids process design considerations.
- Once Phase 1A of the solids improvements is complete, the observed VSR in the digester will provide additional insights to the appropriate value of the influent non-biodegradable VSS.

The solids production estimates identified in Table 2-2 were utilized to estimate digester performance and resulting digested solids loading. Table 2-2 extends the solids mass balances through digestion and dewatering.

Table 2-2: Predicted Solids Mass Loads Through Digestion and Dewatering

Component	Current WWTFs			Future 5-Stage BNR WWTF		
	Average Day ²	Max Month ²	Peak 2-Week ³	Average Day ¹	Max Month ²	Peak 2-Week ³
Total Solids Mass Flows						
Thickened Primary Sludge, lbTSS/d	15,000	19,500	21,000	11,700	15,600	17,800
Nelson TWAS, lbTSS/d	0	0	0	10,900	15,100	17,100
Hauled TWAS, lbTSS/d ³	20,000	16,000	14,600	20,000	26,000	28,000
Co-digestate, lbTSS/d	0	0	0	13,600	13,600	13,600
Digester Feed, lbTSS/d	35,000	35,500	35,600	56,200	70,300	76,400
Digested Sludge, lbTSS/d	21,100	24,100	24,100	28,800	43,500	52,300
Hauled Sludge, lbTSS/d ³	19,400	22,200	22,200	26,800	40,400	48,100
Volatile Solids Mass Flows						
Thickened Primary Sludge, lbVSS/d	12,800	16,600	17,900	10,100	13,500	15,400
Nelson TWAS, lbVSS/d	0	0	0	7,600	11,100	12,500
Hauled TWAS, lbVSS/d ³	15,000	12,000	10,900	15,600	20,300	21,900
Co-digestate, lbVSS/d	0	0	0	11,800	11,800	11,800
Digester Feed, lbVSS/d	27,800	28,600	28,800	45,100	56,700	61,700
Digested Sludge, lbVSS/d	13,900	17,200	17,300	22,000	34,500	37,500
Hauled Sludge, lbVSS/d ³	12,800	15,800	15,900	20,300	31,900	34,500
Hydraulic Flows						
Thickened Primary Sludge, gpd	40,000	52,000	56,000	31,100	41,600	47,400
Nelson TWAS, gpd	0	0	0	26,100	36,200	40,900
Hauled TWAS, gpd	55,800	44,700	40,700	55,800	72,500	78,100
Co-digestate, gpd	0	0	0	23,300	23,300	23,300
Digester Feed, gpd	95,700	96,700	96,700	136,300	173,600	188,700
Digested Sludge, gpd	95,700	96,700	96,700	136,300	173,600	188,700
Hauled Sludge, gpd ³	9,300	10,600	10,600	12,800	19,400	23,100

¹Estimated using lower influent non-biodegradable volatile solids, resulting in a volatile solids reduction near 50%.

²Estimated using higher influent non-biodegradable volatile solids, resulting in a volatile solids reduction near 40%

³Assumes 92% capture and a dewatered cake concentration of 25% TSS

Table 2-3 represents hydraulic and solids loading rates following completion of the Phase 1A project, and for future conditions with the treatment facility upgrade. Under solids production from the current WWTFs, the amount of allowable hauled TWAS from BRM and NCAC was limited to maintain a minimum HRT for class B Biosolids of 15 days. In the future BNR condition, the digestion complex is predicted to be able to handle all of the TWAS produced at BRM and NCAC with additional capacity to received FOG.

As a result of the lower predicted solids production for the future BNR WWTF compared to those presented in the Solids Handling Study, the buildup of the solids expansion may have an increased capacity for hauled sludge or increased FOG. The potential of increased loading should be evaluated during the implementation of future phases of solids expansion.

Table 2-3: Digester Loading at Design Conditions

Parameter	Phase 1A	Future 5-Stage BNR WWTF	Typical Range ¹
Digester's in Service			
Primary	1	3	NA
Secondary	1	1	NA
VSLR, lbVS/d/1000CF²			
Average Day	143	78	
Max Month	148	98	120 to 160
Peak Week	149	106	
HRT, Days			
Average Day	15.1	31.9	
Max Month	15.0	25.1	>15 days
Peak Week ³	15.0	23.1	

¹Water Environment Manual of Practice 8

²Assumes active digester volume is 1.45 MG per digester in-service

³Minimum digester HRT for Class B biosolids is 15 days at peak 2-week loading

3 Building 9 – TWAS Receiving, Sludge Blending and Transfer Pumping

3.1 TWAS Receiving

TWAS from New Century Air and Blue River Main WWTFs are trucked to the Nelson Complex for treatment. Currently, the trucks unload directly to Sludge Holding Tank No. 4; however, with the conversion of this tank to Digester No. 4, the trucked in material needs to be unloaded ahead of the digestion process where it can be blended with the Nelson Complex sludge. This will require a new TWAS receiving facility.

3.1.1 Alternatives Considered

Four alternatives were considered for TWAS receiving at the Nelson Complex. These alternatives included rehabilitating the existing abandoned sludge holding tank located west of the chemical building (Alternative 1), building a new TWAS Receiving sump and pump station (Alternative 2), building a new pump station to pump directly to Blend Tanks No. 1 and 2 (Alternative 3), and pumping directly to the blend tanks (similar to Alternative 3) from pumps located in the southeast corner of Building No. 12 (Alternative 4). Alternative locations are shown in Figure 3-1.

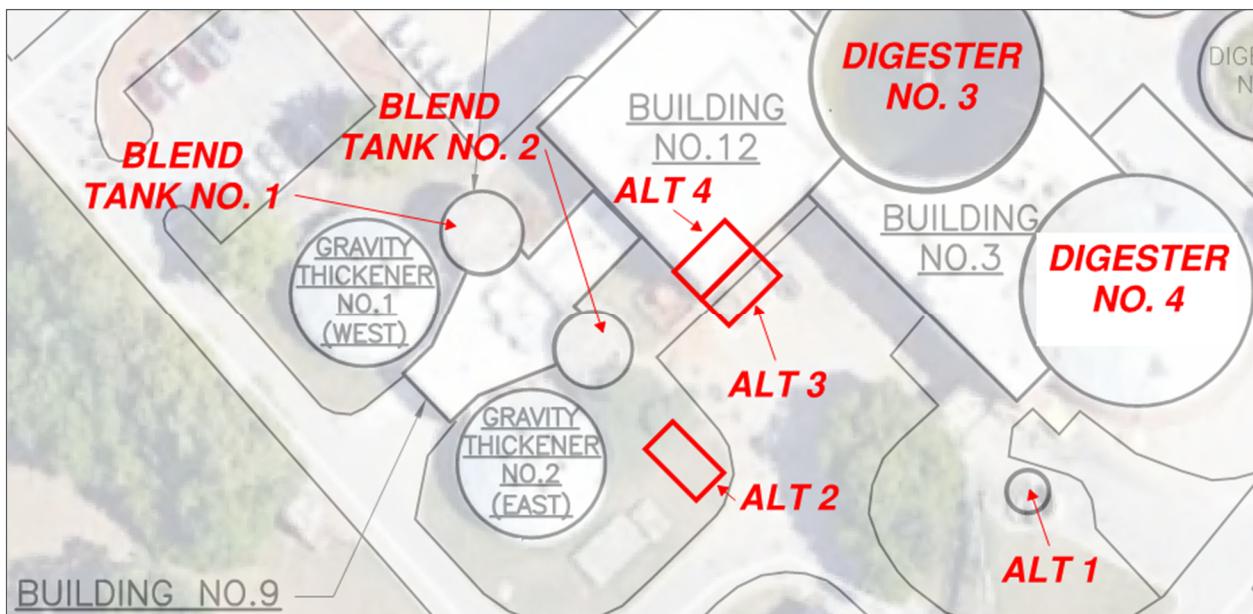


Figure 3-1: TWAS Receiving Alternative Locations

The abandoned sludge holding tank shown as Alternative 1 was built in 1956. The tank was originally designed to transfer sludge to and from Sludge Holding Tanks No. 3 (designated as Digester No. 3 in figure above) and No. 4, as well as send sludge to the sludge drying beds. In Contract 47 (1998) the two suction lines and supernatant overflow line were removed to make room for the new chemical storage area. Proposed modifications under Alternative 1 included the addition of a mechanical mixer and concrete baffles along the sidewall and cone to aid in mixing efficiency, new suction lines, two new pumps and a new pipeline to convey the TWAS to

Blend Tanks No. 1 and No. 2. This location only allows one truck to offload at a time, a deep excavation would be required next to the building foundation for suction pipe installation, and the pumping distance is the greatest of the four options. For these reasons, this alternative was not selected.

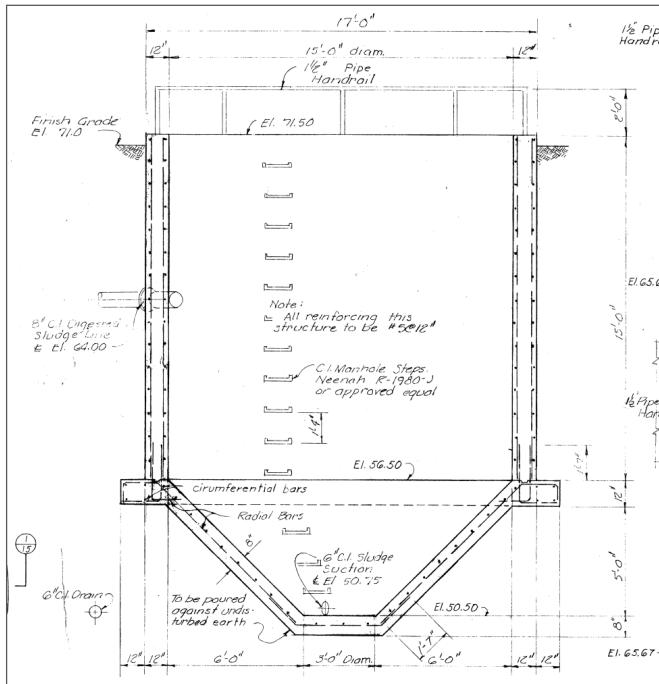


Figure 3-2: Existing Receiving Sump, 1956 Contract 2 (ALT 1)

Alternative 2 includes building a new TWAS receiving sump and pump station. The new sump and pump station would be located below grade adjacent to Gravity Thickener No. 2. This proposed alternative would include a new receiving sump, mechanical mixer, new pumps, and a new below-grade pump station. The selected location on the site has several underground utilities within the area. This option was not selected due to these construction constraints and because the below grade pump station would be a confined space. An elevation view of Alternative 2 is shown in Figure 3-3.

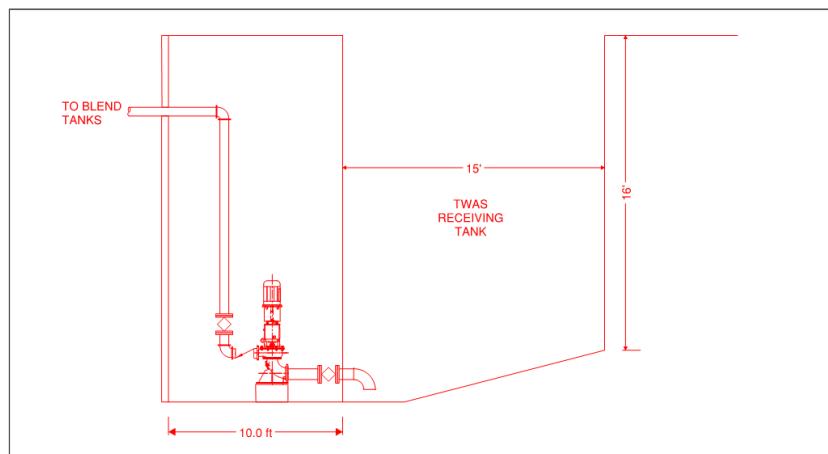


Figure 3-3: Proposed TWAS Pump Station and Receiving Sump (ALT 2)

Alternative 3, shown in Figure 3-4, is a new structure located at grade level adjacent to the southeast corner of the Incineration Building (Building No. 12). This alternative would include three truck offloading lanes, three pumps, and redundant pipelines to the Blend Tank No. 1 and No. 2. This alternative is a direct pump from the trucks to the Blend Tanks and does not require a receiving tank or sump for storage.

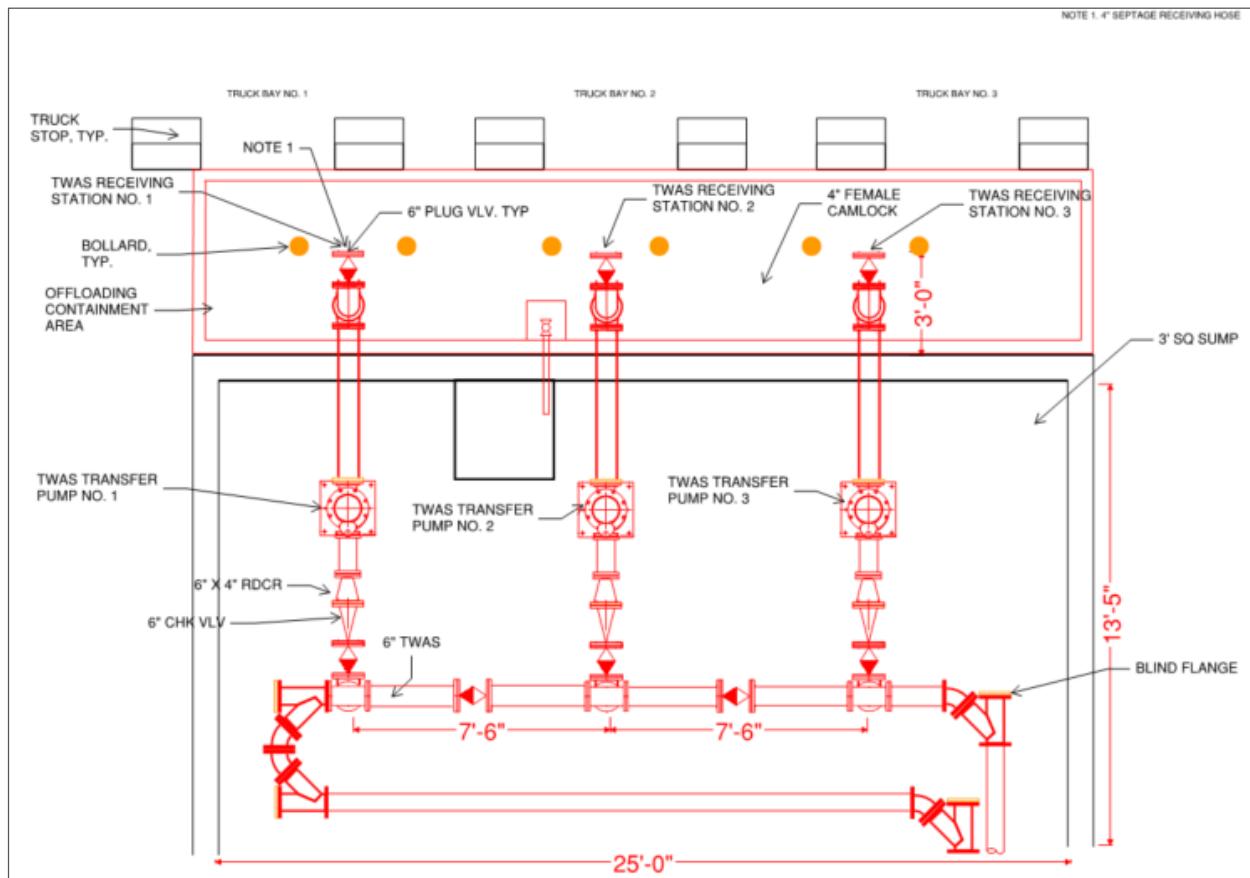


Figure 3-4: TWAS Structure with Pumps Outside Building 12 (ALT 3)

Alternative 4, shown in Figure 3-5, is similar to the configuration in Alternative 3, however the pumps would be located within the southeast corner of Building 12.

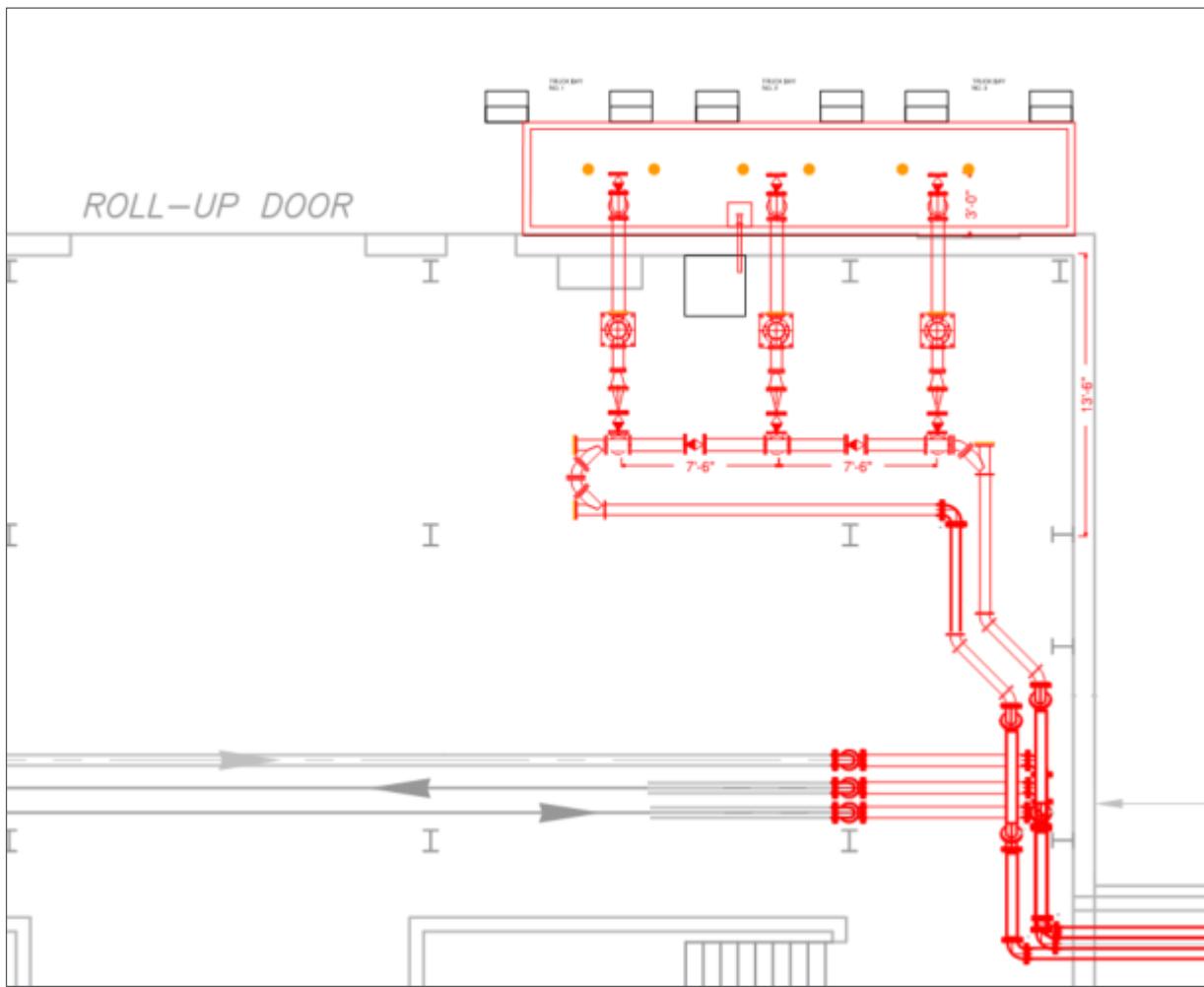


Figure 3-5: TWAS Structure with Pumps Inside Building 12 (ALT 4)

3.1.2 Proposed Improvements

The selected alternative is Alternative 4. This alternative would be less costly than Alternative 3 in that a separate building enclosure would not be required. The TWAS Receiving Station will be located in the southeast corner of the existing Incineration Building (Bldg. No. 12). The facility will receive and pump trucked in TWAS to Blend Tanks No. 1 and No. 2. For sizing of equipment, it is assumed that trucked in TWAS is only accepted for eight hours per day and generally is not accepted on the weekends.

3.1.2.1 FACILITY DESCRIPTION

Table 3-1 defines the key TWAS receiving parameters. Three offloading bays will be provided to allow for multiple delivery offloads simultaneously. The offloading area will have truck stops to prevent the trucks from backing into the facility. Along the east wall, three truck connection stations will be located to allow for the trucks to connect to the suction side of the pumps. A containment curb will be provided around the offloading area in the event spills occur during connection and disconnection from the truck.

The Receiving Station will consist of three vertical chopper pumps, valving and controls. One pump will be dedicated to each offloading bay. The discharge of each pump will consist of an automated

isolation valve and check valve. Redundant pipelines will be provided from the Station to the Blend Tanks in the event one of the lines is taken down for maintenance. Each line will be able to feed either Blend Tank.

Table 3-1: TWAS Receiving Facility Data

Criteria	Value	Unit
Offloading Bays	3	Each
Tanker Size (Typical)	3,900	Gallons
Unloading Time (Min/Max)	10	Minutes
Required Flow Rate, per pump (Min / Max)	390	GPM
Required Pump TDH (Min/Max)	115	Ft
Required Number of Pumps	1 dedicated per truck	#
Pump Type	Vertical Chopper	
Pump Motor Size	15	HP

3.1.2.2 ACCESS AND MAINTENANCE

Pumps will be accessible on three sides with a minimum of 3 feet clearance in any given direction.

3.1.2.3 PROCESS CONTROL DESCRIPTION

When a truck is ready to offload TWAS, the driver will connect the truck to the receiving station via the flexible hose. Once connected the operator will confirm that Blend Tank No. 1 or No. 2 has sufficient volume capacity to receive TWAS and that the appropriate valves are open. Once confirmed, the operator will start the pump, open the discharge valve and begin to withdraw from the tanker. After the transfer is complete the, the pump is shut down, the discharge valve is closed, and the hose is removed from the truck.

3.1.3 Probable Cost Summary

A breakdown of the TWAS Improvement costs is shown in Table 3-2.

Table 3-2: TWAS Receiving Probable Cost Summary

Building/Structure	\$34,000
Equipment & Piping	\$116,000
Electrical/I&C	\$50,000
Related Work Allowances	\$48,000
Subtotal:	\$248,000
Contractor Markups & Contingency*	\$164,000
Total Construction Cost	\$412,000
Engineering, Legal, Admin (27.5%)	\$113,000
Total Cost	\$525,000

* Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

3.2 Blend Tanks

The existing Sludge Holding Tanks No. 1 and No. 2 will be converted to Blend Tanks to accept and blend the Nelson Complex thickened solids with the trucked in TWAS. Rehabilitation of the tanks and the addition of mixers will be required.

3.2.1 Alternatives Considered

The Sludge Holding Tank No. 1 and No. 2 were built in 1973 as a part of Contract 11. The tanks were designed to receive thickened sludge from the gravity thickeners. Currently, the tanks provide additional storage capacity in the solids process. Sludge can be pumped from the tanks to Sludge Holding Tank No. 4 or directly to the centrifuges for dewatering. Original construction included a mechanical mixer for keeping the contents suspended within the tank. Currently, no mixing system is installed. This project will convert the existing Sludge Holding Tank No. 1 and No. 2 into Blend Tanks No.1 and No. 2. Three mixing technologies were considered for the blend tanks. The three options considered were mechanical mixing, linear motion mixing, and hydraulic (jet) mixing. Figure 3-6 below provides a section view of the original Sludge Holding Tanks.

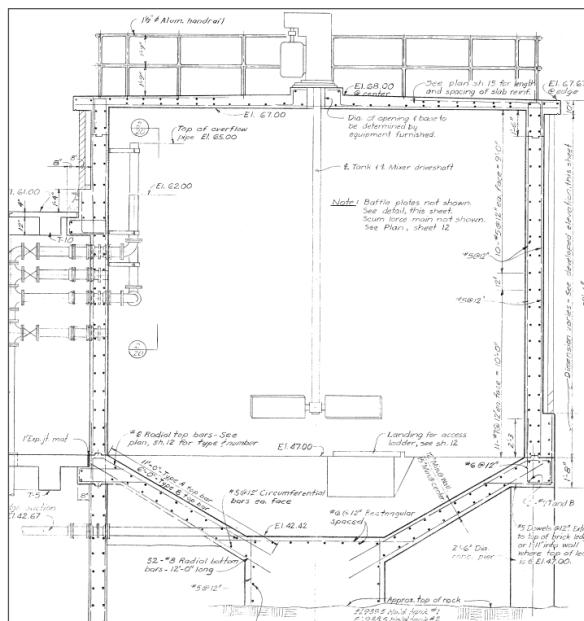


Figure 3-6: Sludge Holding Tanks, 1973 Contract 11

3.2.1.1 MECHANICAL MIXING

Mechanical mixing with the mixer suspended from the tank roof, similar to that shown in Figure 3-6, uniformly mixes tank contents with higher mixing energy than other types of mixing. Baffles walls would be required on the sidewall and on the cone to ensure that the contents are sufficiently mixed. Since the tanks were designed to accommodate top-mounted mixers, no additional modification to the tank would be required to mount the mixer.

3.2.1.2 LINEAR MOTION MIXING

Linear Motion mixing utilizes up and down movement of a ring-shaped hydro-disk driven by a motor outside of the tank. The oscillating velocity coupled with pulsating pressure waves and velocity produces a uniform mixture within the tank. Since linear motion doesn't rotate, it's less prone to ragging. Linear motion mixers mount in a similar fashion to mechanical mixers with the motor and gearbox located on the top of the tank.

3.2.1.3 JET MIXING

Jet mixing systems would require a two-nozzle configuration and an externally located duty pump rated for 430 gpm. Pumped mixing systems generally pump from the center of a coned bottom to help re-suspend any sludge that may accumulate at this location. Due to the configuration of Building 9, the motive pumps would need to be located at the lowest level to keep the pumps with a flooded suction when the tank is at its lowest levels. The lowest level does not have the appropriate space to allow for sufficient access during maintenance of the new pumps and would cut off access to the existing pumps within the space.

3.2.1.4 SELECTED MIXING SYSTEM

The selected mixing system for the Blend Tanks is mechanical mixing. Due to the space constraints as noted for the hydraulic mixing, as well as the increased cost for both the hydraulic and linear motion mixer, mechanical mixing was selected as the preferred alternative. Shown in Table 3-3 is the cost for each system, as well as, the cost differential. This cost comparison includes all construction, engineering, legal, and administrative markups.

Table 3-3: Mixing Cost Comparison

Type of Mixing	Total Cost	Cost Difference
Mechanical	\$545,000	Base Line
Hydraulic	\$581,000	\$36,000
Linear	\$1,026,000	\$481,000

3.2.2 Proposed Improvements

3.2.2.1 DESIGN CRITERIA

Blend Tanks No. 1 and No. 2 will be utilized to blend and equalize flows from the Gravity Thickeners and TWAS from the TWAS Receiving Station prior to being pumped to the anaerobic digesters. Sludge can be pumped from the Blend Tanks to Digester No. 3, Secondary Digester No. 4, or the centrifuges with existing pumps and piping. Table 3-4 below highlights the process design criteria for the Blend Tanks.

Table 3-4: Blend Tank No.1 and No.2 Design Criteria

Criteria	Current		Future *	
	AD	MM	AD	MM
Design Condition				
Flows, gpd	87,900	99,900	74,000	79,800
TSS Load, lbs/day	35,000	45,500	30,900	39,300
% Solids	4.8	5.5	5.0	5.9

* Assuming tanks are retained in BNR expansion

3.2.2.2 PROCESS MECHANICAL

Table 3-5 lists the process mechanical design parameters for the mechanical mixers.

Table 3-5: Mechanical Mixers Design Criteria

Criteria	Value	Unit
Mixer Type	Mechanical	-
Number of Mixers	1, each tank	Each
Mixer Motor	10	HP
Wetted Materials	316SS	-
Mount Location	Roof-Mounted	-

3.2.2.3 ACCESS AND MAINTENANCE

Each Blend Tank has an existing hatch located in the tank cover. The hatch can be used to access the tank internals and mixer components. Adequate space is provided for maintenance activities. The mixers would be removed with a crane or other lifting rig.

3.2.2.4 STRUCTURAL REHABILITATION

The concrete of Blend Tanks 1 and 2 has experienced substantial H₂S attack on the interior ceiling and upper wall surfaces. Some aggregate and isolated areas of steel reinforcement have been exposed. Rehabilitation of the tank surface is recommended prior to use. Rehabilitation measures include removing loose concrete on the tank walls and underside of the top slab, application of mortar spot repair where required, and application of an epoxy lining system. Additional equipment pads or mixer supports will be installed as required to support the selected equipment.

3.3 Transfer Pumping

3.3.1 Centrifuge Feed Pumps (Building 9 Intermediate Level)

The existing centrifuge feed pumps located within Building 9 are near the end of their existing life and will be considered for replacement in kind. The pump design criteria are shown in Table 3-6.

Table 3-6: Centrifuge Feed Pump Design Criteria

Criteria	Value	Unit
Pump Type	Progressing Cavity	-
Number of Pumps	1 Duty / 1 Standby	-
Design Flow Rate	165	GPM
Design Head	135	Feet
Design Speed	242	RPM
Motor Horsepower	20	HP
Suction Nozzle Size	8	Inch
Discharge Nozzle Size	8	Inch

3.3.2 Pipe Condition Assessment

During Contract CMSD-C020 construction improvements to the sludge transfer piping, JCW plant staff identified several instances of delaminating piping within the midlevel of Building 9. The sludge piping installed during Contract MTM1-C042 in 1995 used a polyurethane coated ductile iron pipe on the centrifuge transfer pump suction header, discharge header, and sludge transfer lines to the Centrifuge Building (Building 14). The polyurethane lining has started to detach from the ductile iron pipe. The transfer lines were replaced from the Building 9 wall penetration to Building 14 as part of the Contract 20 improvements. It is recommended to replace the ductile iron piping from the centrifuge transfer pump discharge header to the building penetration where the transfer lines exit Building 9. This amounts to approximately 145 feet of 6 inch ductile iron pipe.

3.4 Electrical

The Main Switchgear located on the east side of the plant feeds 480V, 3-phase underground to Motor Control Center 9, MCC-7009. MCC-7009 is located on the Main Level of Building 9 as shown on Sheet 09E101, located in Appendix A5. It is rated 480V, 3-phase, 800A. Based on load calculations for the existing equipment, the MCC has a connected load of 240A. The total running load as a part of this scope is anticipated to be 344A. Therefore the MCC rating is adequate for the new loads.

Physically, the MCC does not have adequate spare space available for additional breakers or motor starters, and an additional section cannot be added to the MCC due to space limitations. However, existing circuit breakers that are 12" high can be replaced with two circuit breakers that are 6" high. Consolidating the breakers would create space within the MCC so that new circuit breakers and motor starters could be added. The required MCC demolition is shown on Sheet 09X601 in Appendix A5. The new MCC one line diagram and elevation is shown on Sheets 09E601 and 09E602 located in Appendix A5.

3.5 Instrumentation

Building 9 contains an Allen-Bradley ControlLogix Remote I/O rack located in LCP-7002 that is connected to the Building 3 Network Rack via fiber optic cable as shown on Sheet 00Y601 (Appendix A6). The Remote I/O rack has adequate spare slots to add new cards for the I/O anticipated for this project, therefore, a new PLC is not anticipated.

The P&ID Sheets 00Y602 and 00Y603 (Appendix A6) show the I/O points that are proposed for the TWAS pumps and the sludge blend tank mixers.

3.6 Building 9 Space Classification Evaluation

Due to the ventilation and air changes provided through the Contract 20 improvements, Building 9 is unclassified. The space within the gravity thickeners and sludge holding tanks is Class I Division 1 (CID1). The common path of egress travel from the lowest level is 80' 6", which exceeds the International Building Code (IBC) 75' 0" limit allowed for a non-sprinklered Group F industrial occupancy. Given the future plans for the complex, the existing nonconforming condition can likely remain. The lower and middle levels currently have Lower Explosive Limit (LEL) combustible gas detection, H2S gas detection, and audio and visual notification devices installed through Contract 20. The Gas Detection/Ventilation Panel is located by the south exterior door on the upper level of Building 9. A drawing of the Building 9 space classification evaluation can be found in Appendix A2.

3.7 Probable Cost Summary

A breakdown of the Building 9 Improvements is shown in Table 3-7.

Table 3-7: Building 9 Improvements Probable Cost Summary

Base Scope

Building/Structure	\$93,000
Equipment & Piping	\$348,000
Electrical/I&C	\$40,000
Related Work Allowances	\$82,000
Subtotal:	\$564,000
Contractor Markups & Contingency*	\$373,000
Total Construction Cost	\$937,000
Engineering, Legal, Admin (27.5%)	\$258,000
Total Cost	\$1,195,000

* Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

Potential Adders (Total Costs)

Hydraulic Mixing	\$36,000
Linear Motion Mixing	\$481,000

Potential Deducts (Total Costs)

Delaminated Pipe and Centrifuge Pump Replacement	\$325,000
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3.8 Proposed Solutions and Decisions

3.8.1 TWAS Receiving

- Selected Alternate 4, with the sludge transfer pumps located within Building 12 and hauled sludge receiving stations located in a drive-up area outside the building.
- Sludge hauling trucks will go around the Mission Main loop, then back into the unloading area after turning the corner at Building 4, see Figure 0-1 in the Executive Summary.
- Drivers will utilizing the gravel area next to Digester 4 as a staging area if another sludge hauling truck is currently backing up, see Figure 0-1 in the Executive Summary.
- Added isolation walls within Building 12 around the sludge transfer pumps in order to create an unclassified space, with new HVAC providing 6 air changes per hour.
- Included a pipe spool ahead of the transfer pumps for the future installation of grinders if ragging becomes an issue.
- See Figure 0-2 in the Executive Summary for the TWAS area layout.

3.8.2 Blend Tanks

- Selected roof mounted mechanical mixing.
- Interior tank improvements including baffles and surface recoating.
- Tank lid improvements including a mixer support pad and new access hatch.

3.8.3 Transfer Pumping

- The delaminated pipe and centrifuge feed pumps within Building 9 will remain as is. These items will be replaced in the future in the event of failure.

3.8.4 30% Cost Estimate for TWAS and Building 9 Improvements

The updated 30% Design cost estimates for the TWAS Area and Building 9 Improvements are shown below:

TWAS: Construction Costs

Building/Structure	\$50,000
Equipment & Piping	\$132,000
Electrical/I&C	\$48,000
Related Work Allowances	\$51,000
Subtotal:	\$281,000
Contractor Markups & Contingency*	\$174,000
Total Construction Cost	\$455,000
Engineering, Legal, Admin (27.5%)	\$125,000
Total Cost	\$580,000

* Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

Building 9: Blend Tanks and Transfer Pumping

Building/Structure	\$97,000
Equipment & Piping	\$348,000
Electrical/I&C	\$42,000
Related Work Allowances	\$94,000
Subtotal:	\$582,000
Contractor Markups & Contingency*	\$385,000
Total Construction Cost	\$966,000
Engineering, Legal, Admin (27.5%)	\$266,000
Total Cost	\$1,232,000

* Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

4 Building 3 - Anaerobic Digestion and Odor Control

4.1 General

The anaerobic sludge digestion process utilizes anaerobic microorganisms, which are primarily bacteria that live without free oxygen. These bacteria decompose and stabilize the highly putrescible organic materials in wastewater sludge. Following anaerobic digestion, stabilized sludge can be disposed on agricultural land with less chance of an odor or vector attraction nuisance. Digestion reduces the volume of sludge to be disposed and, in the process, produces gas, primarily methane, which can be burned to produce electricity or to heat water for use in building and digester heating. Building 3 and the tankage were built in 1956 under Contract 2 and were originally designed as anaerobic digesters, however, in the 1970's digestion was discontinued and the digester support equipment was removed. In Contract CMSD-CO20, the abandoned Digester No. 4 was converted into a sludge holding tank, Sludge Holding Tank No. 4, including external pumps and an internal jet mixing system. The proposed Phase 1A modifications include converting existing abandoned Digester No. 3 back to a primary anaerobic Digester No. 3, converting Sludge Holding Tank No. 4 to secondary anaerobic Digester No. 4, installing digester support equipment, and new covers for both Digester No. 3 and No. 4.

4.2 Design Criteria

Process Design Criteria for the anaerobic digestion process can be found in Section 4.3 through Section 4.7.

4.3 Process Mechanical

4.3.1 Digester Mixing System

In Contract 20, a pumped jet mixing system was installed within Sludge Holding Tank No. 4 (Digester No. 4). Anticipating that existing Digester No. 3 would be brought back into service, a new piped suction line was installed to Digester No. 3, and redundant mixing pumps were provided. A mixing system within Digester No. 3 was not installed as a part of that contract. The existing mixing pumps will be reused for mixing for both Digester No. 3 and No. 4. This will provide one installed pump for each digester, plus a shared shelf-spare will be added. A new four-nozzle mixing header, identical to the mixing header located with Digester No. 4, will be installed within Digester No. 3. The suction and discharge piping will be reconfigured to allow for one pump to be dedicated to each digester.

4.3.2 Digested Sludge Transfer

Digested sludge will be transferred from Digester No. 3 to secondary Digester No. 4 by utilizing the existing overflow pipe that currently connects the two digesters together. A weir box will be provided around one of the two openings, as shown in the Figure below, to provide level control with each digester. This will allow either digester to be operated a primary digester, as well as allow Digester No. 4 to be operated as a secondary digester for the future BNR upgrade. To allow for free discharge into either digester for efficient transferring of digested sludge, a wye fitting and plug valves will be provided to bypass the weir box. See Figure 4-1 below.

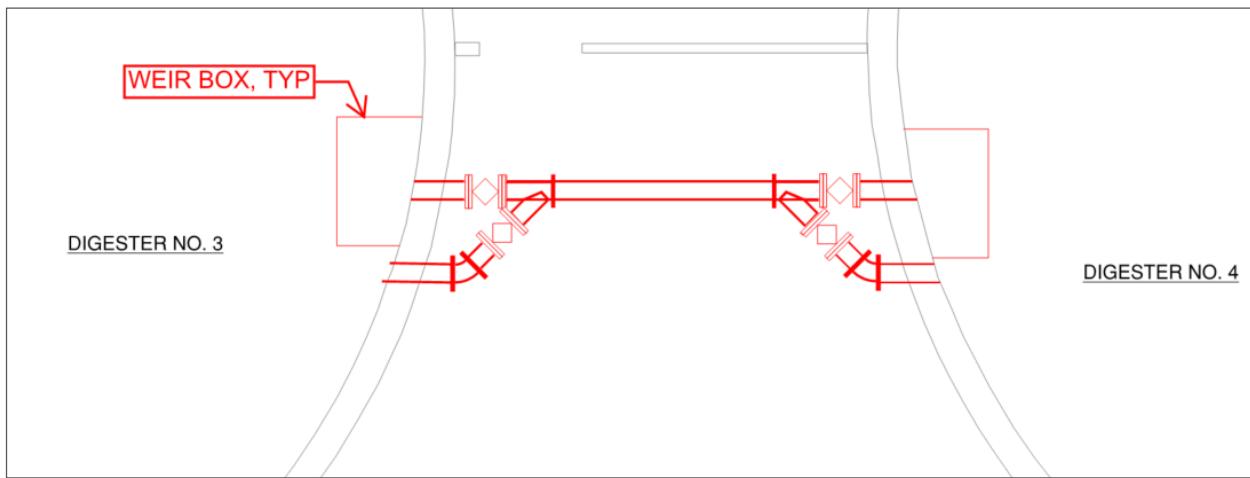


Figure 4-1. Digester Overflow Piping Modifications

4.3.3 Digester Heating and Transfer Pumping

For Phase 1A, only Digester 3 will be retrofitted with the necessary heating equipment. When Sludge Holding Tank No. 4/Digester No. 4 becomes a secondary digester during the future BNR upgrade, the required heating equipment will be provided then. The sludge heating system will utilize a hot water boiler, counterflow tube-in-tube heat exchanger, and sludge heating pumps to heat the incoming and digester side stream to keep the contents of the digester at the design temperature of approximately 100 degrees Fahrenheit. The flow from Blend Tanks No. 1 and No. 2 will be mixed and pre-heated with a digested sludge side stream from the sludge heating pumps. Once mixed, the combined flow stream will be heated to the design temperature of the digester through the heat exchanger and will discharge into the digester. Digester heat loss calculations to the environment are shown in Table 4-1. Sludge heating requirements are shown in Table 4-2.

Table 4-1: Digester Heat Loss Calculations

Digester No. 3			
Temperatures	Value	Units	Notes
Below grade temperature	55	Deg F	
Air temperature	5	Deg F	
Sludge temperature	100	Deg F	
Inside air temperature	60	Deg F	
Overall Coefficient of heat transfer (U)			
Digester cover	0.91	Btuh/(sq ft.*deg F)	Fixed steel cover
Sides (Outside)	0.3	Btuh/(sq ft.*deg F)	concrete wall w/air gap and brick
Below grade	0.5	Btuh/(sq ft.*deg F)	Concrete wall or floor (12 inch thick) exposed to wet earth (10 feet thick)
Sides (Insides)	0.9	Btuh/(sq ft.*deg F)	18" wall
Dimensions			
Digester diameter (inside)	80	ft	Total diameter of digester
Digester SW Height (to air - Building)	37.5	ft	SW=Side Wall.
Percentage of Circumference	53	%	Percentage of diameter that is exposed to building space
Digester SW height (above grade)	16.67	ft	
Percentage of Circumference	47	%	Percentage of diameter that is exposed to outside air above grade
Digester SW height (below grade)	20.83	ft	
Percentage of Circumference	47	%	Percentage of diameter that is exposed – below grade
AREA			
Digester cover	5404	sq. ft.	$A=2*pi*r*h$
Above grade Sidewalls (Outside)	1962	sq. ft.	
Below grade + Cone	7855	sq. ft.	
Above grade SW (Inside)	5012	sq. ft.	
Heat Loss			
Digester cover	467,100	Btuh	$Q=U*A*dT$
Above grade Sidewalls (Outside)	55,900	Btuh	
Below grade + Cone	176,700	Btuh	
Above grade SW (Inside)	<u>225,500</u>	Btuh	
Total	699,700	Btuh	

Table 4-2: Sludge Heating Requirements

Criteria	Value	Unit
Sludge Flow	124,560	gpd
Sludge Temp	70	deg F
Mixing Flow	288,000	gpd
Mixing Temp	100	deg F
Start temp, blended	90.9	deg F
End temp, blended	100	deg F
Density	8.34	lbm/gallon
Specific heat, Cp	1	BTU/lbm deg F
Total	1,298,538	BTU/hr.

Approximately 2.0 MMBTU/hr (heating requirements from the liquid plus the heat lost from the digester) is required to maintain the sludge temperature within the digester. Process mechanical parameters for the boiler, heat exchanger, sludge heating pumps, and hot water recirculation pumps can be found in Table 4-3.

Table 4-3: Digester Support Equipment Design Criteria

Criteria	Value	Unit
Sludge Heating Pumps		
Sludge Heating Pumps	Flow Induced Centrifugal Pumps	-
Number of Pumps	1 Duty / 1 Standby	#
Rated Flow Rate	200	GPM
Rated Discharge Pressure	100	ft
Motor Size	20	HP
Boiler		
Quantity	1 Duty / 1 Standby	#
Type	Fire Tube	-
Heating Capacity	2,500,000	BTU/HR
Blower Motor Size	0.75	HP
Control Panel Service	460	V
Heat Exchanger		
Quantity	1 Duty / 0 Standby	#
Heating Capacity	2,500,000	BTU/HR
Type	Concentric Tube, Counterflow	-

The heat exchanger, boiler, and recirculation pumps will be located on the upper level of Building 3. The sludge heating pumps will be located on the lower level of Building 3 near the centrifuge feed pumps and odor control scrubber.

4.3.4 Hot Water System

The hot water system for heating and maintaining sludge temperature within the digester will consist of multiple hot water loops. The primary hot water loop will be supplied from the boiler loop and will convey the hot water to the heat exchanger hot water loops. The boiler hot water loop will maintain a constant temperature setpoint within the primary hot water loop with the use of a boiler feed pump and a three-way mixing valve. The mixing valve will be located upstream of the boiler feed pump and will actuate to provide a constant temperature in the primary heating loop. This is accomplished by only allowing small amounts of water from the primary loop recirculate through the boiler if the temperature setpoint within the primary loop is relatively close. If the main loop is getting cooler, the mixing valve upstream of the boiler will open more and send more water through the boiler to be heated. If the primary loop is getting too warm, the valve will close sending less water through the boiler. The hot water loop will be pressurized with a loop pump that will maintain pressure in the loop. The heat exchanger loop will be utilized to provide a constant temperature to the heat exchanger. A control valve on the discharge (cool) water side of the heat exchanger will be utilized to control the inlet temperature setpoint to the heat exchanger. Without this valve there is a risk of over-heating the sludge within the heat exchanger. Figure 4-2 highlights the piping layout for the hot water system located within Building 3. Blue represents the boiler hot water loop, red represents the primary hot water loop, and green represents the heat exchanger hot water loop. This is the base case for digester heating. There is also an alternative layout with a new building to the northwest which would house the digester heating equipment. This alternate will be discussed in Section 4.11

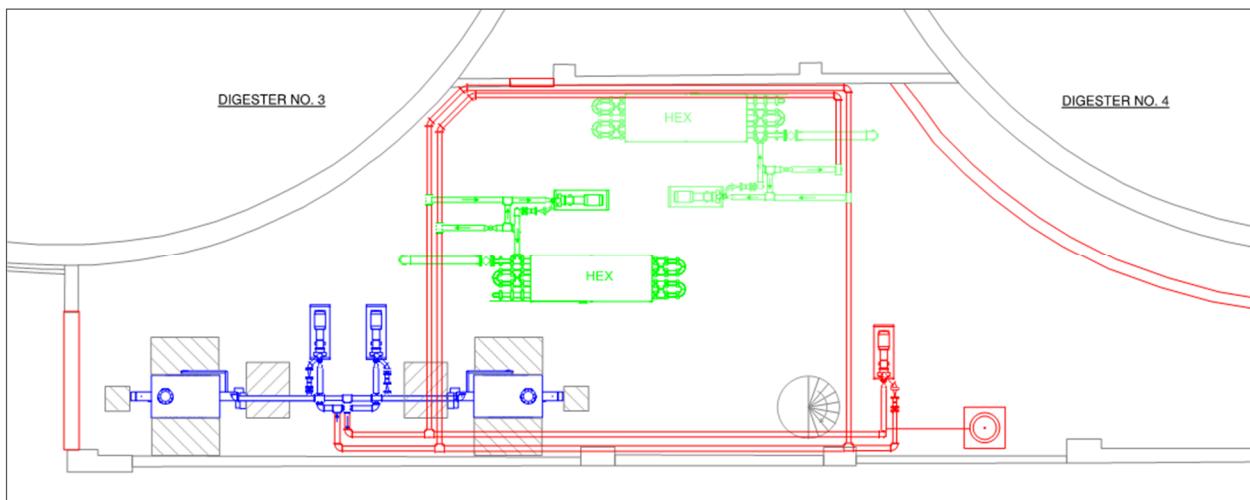


Figure 4-2: Hot Water System Piping Layout

4.3.5 Digester Gas Handling and Flaring

Currently, Digester No. 3 does not have a cover. To ensure the biogas is captured and sent to the flare and a biogas reuse system in the future, a new fixed cover will be added to Digester No. 3. The existing cover on Sludge Holding Tank No. 4 will be replaced with a similar cover, converting it to Digester No. 4. Two enclosed flares, one duty and one standby, will be used to burn the biogas produced by digestion. The flares will be located northwest of Digester No. 3 and south of existing Intermediate Clarifier No. 4.

4.4 Digester Covers

4.4.1 Process Mechanical

New fixed steel covers will be fitted to Digester No. 3 and No. 4. Each cover will be fitted with two 36" manways, redundant pressure relief valve nozzles, and biogas connections to each digester and the flares. Table 4-4 highlights key parameter for the fixed steel covers. Each digester cover will also be equipped with a flame arrestor to maintain safe operating conditions within the digester cover.

Table 4-4: Digester Cover Design Criteria

Criteria	Value	Unit
Type	Fixed	-
Diameter	80	Feet
Quantity	1, each tank	#
Materials	Steel	-
Design Pressure	20	Inches W.C.

4.4.2 Structural

Structural design criteria for the fixed covers will be established in the specification based on industry standards and JCW experience with fixed covers at the DLSMB Plant. The design will be furnished by the cover manufacturer, but the specification will require that the cover drawings and calculations be sealed by a Kansas Professional Engineer.

The existing concrete tanks will be used with minimal structural modifications. The top of the existing concrete walls are partially covered by roofing and have a small step at the exterior walls of Building No. 3. A new concrete cap wall will be placed on top of the existing wall to provide a level surface for mounting the fixed covers. The roofing will be modified with flashing at the wall cap. The guide channels in the walls for the old floating covers will be coated and filled near the top of the wall where the fixed cover skirt provides the perimeter gas seal.

4.5 Process Control Narrative

4.5.1 Digester Mixing

Mixing is essential for efficient digester operation. Mixing prevents stratification, promotes the proper seeding of the incoming sludge with organisms, breaks up scum at the liquid surface, and maintains a uniform temperature profile. Continuous mixing is the preferred mode of operation when the digester is operated at the upper level of the recommended volatile solids loading. Based on acceptable operational experience, primary digesters could be mixed intermittently, and benefit from a reduction in power requirements. The latter benefit may not be significant if the feed sludge is significantly thickened or concentrated before digestion, particularly if a substantial portion of the feed is waste activated biological sludge. The best mode of mixer operation is determined by trial, starting with continuous mixing, and then proceeding to intermittent mixing schedules, increasing the proportion of off-time. Volatile suspended solids reduction and gas production can be used to gauge the effectiveness of mixing system operation. Mixing equipment is also normally operated when sludge is being circulated through external heat exchangers for digester temperature control.

In order for the mixing to operate correctly, the manual suction and discharge valves must be in the open position and the pump should be in "ON". The operator can adjust the amount of mixing by adjusting the pumps speed through the plant control system.

4.5.2 Sludge Heating

The sludge is heated by pumping it through a hot water heat exchanger and returning it to the digester. These recirculation pumps are constant speed, rotary lobe pumps. The anaerobic bacteria essential to the sludge digestion process operate most efficiently in a temperature range of 86 to 104° F. At appreciably higher or lower temperatures, the rate of mesophilic digestion decreases. The most important objective is to maintain a relatively constant temperature; the specific temperature is second in importance. The bacteria show their sensitivity to rapid changes in temperature by reduced gas production. It is important to never allow the temperature to change more than 1.5° F per day to allow the bacteria time to adapt. The most economical and efficient operating conditions is determined by experience. The influent sludge from Blend Tanks No. 1 and No. 2 will be pumped to the heat exchanger via the pumps located within Building 9. The influent sludge will then be mixed with the recirculated sludge from the sludge heating pumps located in Building 3 prior to entering the heat exchanger. Once through the heat exchanger the sludge is returned to the digester.

4.6 Centrifuge Feed Pumps (Building 3)

The centrifuge feed pumps will remain as installed. The suction piping will be modified such that the suction line will be moved to the main suction header between Digester No. 3 and No. 4 so that the centrifuge feed pumps can pull from either tank based on which suction valves are open. A grinder will be installed in the suction line.

4.7 Odor Control and Chemical Storage and Feed Facilities

Building 3 houses a chemical odor scrubber to remove odors such as hydrogen sulfide (H_2S). Upgrades of this system are included in the Phase 1A Project.

4.7.1 Odor Sources

The chemical scrubber is designed to handle and treat odorous air (foul air) from the sources listed in Table 4-5.

Table 4-5: Odor Sources

Odor Sources - Building 3 Chemical Scrubber	
Blend Tanks No. 1 and No. 2	2285 cfm, each
TWAS Receiving Sump (New)	50 cfm
Sludge Thickener No. 1 and No. 2	4800 cfm, each
Primary Clarifiers No. 1 and No. 2	1850 cfm, each
Influent Junction Structure	100 cfm
Parshall Flume	70 cfm
Septage Receiving	480 cfm
Grit/Screening	2490 cfm
Grit Channels	900 cfm
Sludge Distribution Box	300 cfm
Intermediate Clarifiers No. 1 and No. 2 & Intermediate Influent Distribution Box	80 cfm
Total	22,340 cfm

4.7.2 Odor Treatment Process Discussion

Currently, JCW only utilizes sodium hypochlorite for odorous air chemical treatment. Due to operational and safety challenges, JCW has elected to not use caustic soda. For this phase of the design, based on discussions with JCW, the proposed design only includes sodium hypochlorite storage and feed. However, sampling is being performed by JCW at the influent and effluent of the scrubber and based on the results a recommendation on the chemicals that should be used will be developed. A detailed discussion of the chemistry and process design for chemical scrubbers such as that employed at the Nelson Complex is included in Appendix A3

4.7.3 Process Mechanical

The scrubber located within the lower level of Building 3 will remain, however, the fans, recirculation pumps, chemical feed pumps, and chemical tanks will be replaced. The recirculation pumps continuously provide the scrubber with a mixture of water and sodium hypochlorite that is sufficiently distributed across the scrubber packing for adequate removal of odorous compounds.

Table 4-6 lists the design criteria relevant to the proposed upgrade of the chemical scrubber.

Table 4-6: Odor Control Chemical Scrubber Design Data

Criteria	Value	Unit
Chemical Scrubber		
Minimum Odor Removal Rate, H ₂ S	For inlet concentrations > 10 ppmV, 99.9% removal	-
	For inlet concentrations < 10 ppmV, outlet concentration < 10 ppbV	-
Estimated Odor Unit (D/T) Removal Rate	Minimum 90%	%
Process Serviced	Sludge Storage	-
Number of Units	1	#
Type	Scrubbing with Sodium Hydroxide (caustic) and Sodium Hypochlorite (hypo)	
Capacity	20,800	Cfm
Design H ₂ S Concentration (Peak) ¹	41	ppmv
Design H ₂ S Concentration (Avg) ¹	8	ppmv
Scrubber Vessel Diameter	9	Feet
Packing Media Depth	10	Feet
Minimum Bed Retention Time (MBRT)	1.4	Seconds
Estimated Pressure Drop	5	Inches WC
Bulk Sodium Hypochlorite Storage Tank		
Diameter	7	ft
Height	11	ft
Material	FRP	-
Volume	3,000	gal
Days of Storage @ average dose	6	Days
Sodium Hypochlorite Dosing Pumps		
Number of Units	1 Duty / 1 Standby	#
Type	Peristaltic	-
Rating	27.5 @ 150	gph @ psig
Motor Size	0.75	Hp
Drive Type	Variable	-
Recirculation Pump		
Number of Units	1 Duty / 1 Standby	#
Type	Horizontal End	-
Rating	375 @ 60	gpm @ ft
Motor Size	10	Hp
Drive Type	Constant Speed	-
Notes:		
1 Based on 1997 Odor Control Study from black and Veatch report, May 1997.		

4.7.4 Chemical Storage and Feed

The existing chemical feed system that supplies the scrubber with sodium hypochlorite is located in a separate room located in the southeast corner of Building 3. This room contains two fiberglass reinforced plastic (FRP) sodium hypochlorite tanks, one FRP sodium hydroxide tank, and six chemical dosing pumps (two per storage tank). Only one sodium hypochlorite tank and its corresponding dosing pumps are currently being used. All existing tanks, pumps, valves, and process piping for the scrubber and appurtenances will be removed before implementing replacement equipment. Additionally, the elevated concrete equipment pad will be demolished, and the containment wall will be extended to meet the southeast wall of the chemical feed room. The existing eyewash station located in the chemical feed room will remain.

Bulk sodium hypochlorite will be delivered to a new single sodium hypochlorite storage tank via the existing chemical unloading panel and existing hose connection. The existing containment area will be modified such that containment volume will capture the tank volume. This containment area has a low point sump allowing for the collection of any spills or wash down for removal. New chemical dosing pumps will be installed on a wall-mounted panel located on the southeast wall near the entrance to the room. All required accessories such as calibration column, pressure safety valve, and pressure transmitter will also be included on the wall-mounted panel. Due to the potential sodium chloride (chlorine gas) off-gassing, vented ball valves will be used in the chemical feed system. Air relief valves will be added at high points on the sodium hypochlorite systems pump discharge lines to allow off gassing as well. The new recirculation pumps will be installed at the existing location and implement the same piping configuration to/from the scrubber (suction low, discharge high).

A layout of the proposed Chemical Storage and Feed Room is shown in Figure 4-3.

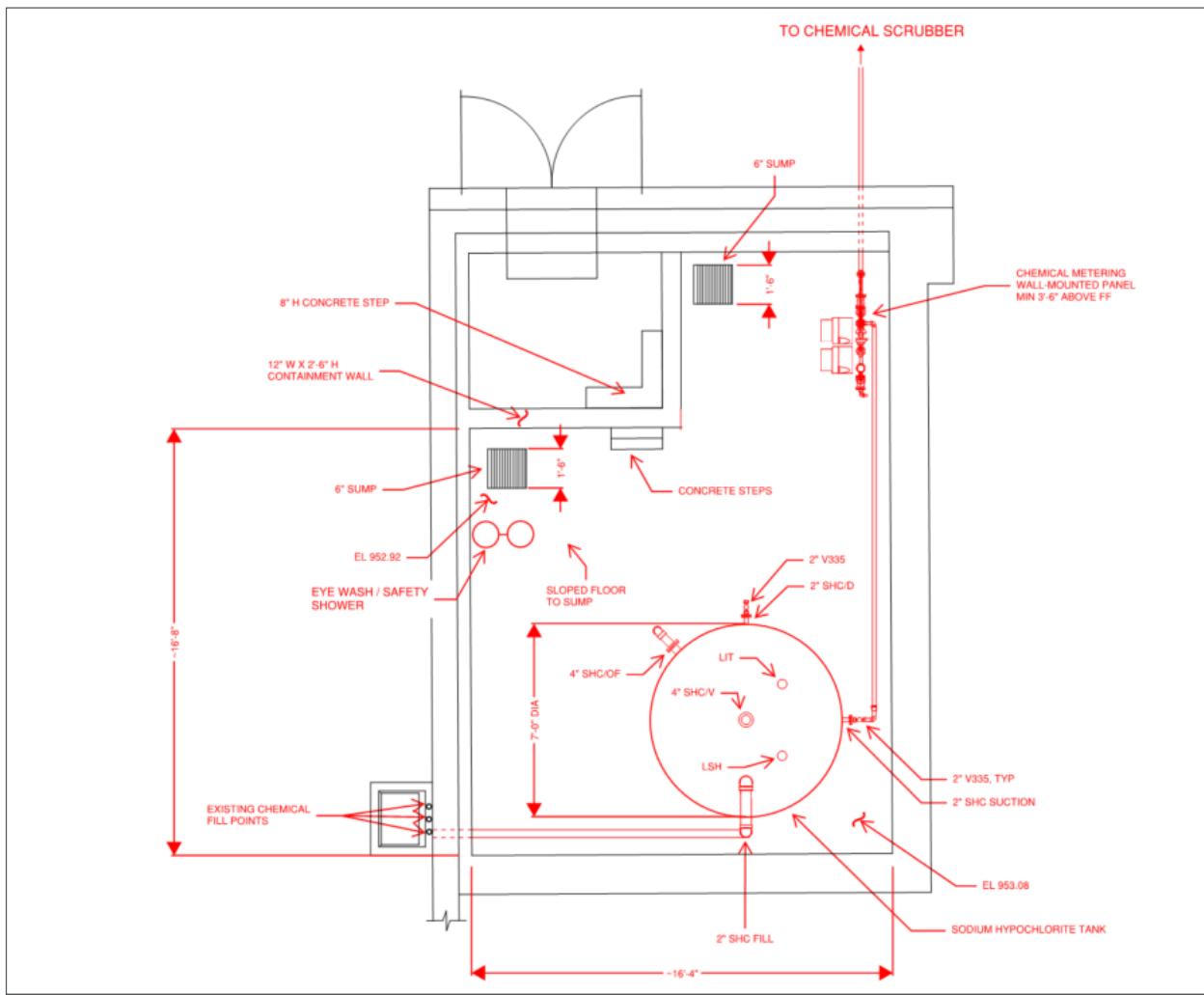


Figure 4-3: Proposed Chemical Storage and Feed Room Layout

4.8 Electrical

The Main Switchgear located on the east side of the plant feeds 480V, 3-phase underground to Motor Control Center 3, MCC-7003. MCC-7003 is located in the Building 3 Electrical Room and is rated 480V, 3-phase, 600A. Based on load calculations for the existing equipment, the MCC has a connected load of 326A. The total running load as a part of this scope is anticipated to be 443A. Therefore the MCC rating is adequate for the new loads.

Physically, the MCC does not have adequate spare space available for the number of breakers required, and an additional section cannot be added to the MCC due to room limitations. Therefore it is proposed that a single 225A breaker be added to the MCC to feed a 480V, 225A power panel as shown on Sheet 03E601 (Appendix A5). A power panel is recommended instead of an MCC vertical section because most of the new loads are control panels and VFDs that are not typically installed in MCCs. The power panel one line diagram is shown on Sheet 03E602 in Appendix A5.

There is adequate space in the center of the electrical room to mount the power panel, VFDs and manufacturer supplied control panels. Sheet 03E101 (Appendix A5) shows a layout of the electrical room demonstrating that the allowable NEC clearance requirements will be met.

4.9 Instrumentation

The Building 3 Electrical Room contains a Network Rack that is connected to the Administration Building via fiber optic cable as shown on Sheet 00Y601 (Appendix A6). An Allen-Bradley ControlLogix PLC is located in LCP-7003 and is connected to the Network Rack switch via CAT 6 cable. The PLC has adequate spare slots to add new cards for the I/O anticipated for this project, therefore a new PLC is not anticipated.

The P&ID Sheets 00Y604 through 00Y607, in Appendix A6, show the I/O points that are proposed for the Flares, Heat Exchanger and Hazardous Gas Detection.

The existing Odor Control Panel contains an Allen Bradley SLC 5/03 that is connected to Building 1 near Digester 2. It will be connected to PLC-7003 as a part of this project.

4.10 Building Space Classification Evaluation

4.10.1 Alternative 1 - Existing

The upper and lower floors of Building 3 currently have less than 12 Air Changes per Hour (ACH) and therefore the entirety of Building 3 (and atmospherically connected spaces) is Class 1 Division 1 (C1D1) due to the shared wall with Digesters 3 and 4. The office structure on the upper floor has combustible construction and its removal is recommended per National Fire Protection Association (NFPA) and IBC codes. The electrical room installed via Contract 20 is unclassified due to isolation and ventilation provided. All equipment in the lower level installed through Contract 20 is C1D1 rated. A drawing of Alternative 1 is located in Appendix A2.

4.10.2 Alternative 2 - Reduce to Class 1 Division 2

In order to decrease the space classification from C1D1 to Class 1 Division 2 (C1D2), provide 12 or more ACH and LEL/H2S gas detection equipment. With these improvements, the entirety of Building 3 (and atmospherically connected spaces) would be C1D2. The space within the digesters and a 5' envelope outside the digester walls will still be C1D1. New equipment installed would be C1D2 rated. A drawing of Alternative 2 is located in Appendix A2.

4.10.3 Alternative 3 – Unclassified Upstairs and Downstairs with Digester Liner

In addition to the ACH and LEL/H2S gas detection equipment in Alternative 2, Alternative 3 also includes the installation of a polyurethane liner to the interior walls of Digesters 3 and 4. With the Authority Having Jurisdiction's (AHJ) approval, installation of the liner would create an unclassified space for the entirety of Building 3 (and atmospherically connected spaces). AHJ approval for this approach is required since the actual code complaint methodology calls for a separate isolation wall between the digester wall and the space in question. The liner is intended to achieve the same result, but is not cited in the code as an approved method. The polyurethane liner would provide a secondary isolation barrier from the digested sludge and interior space. New equipment installed in this alternative would be unclassified. A drawing of Alternative 3 is located in Appendix A2.

4.10.4 Alternative 4 – Unclassified Upstairs, Class 1 Division 2 Downstairs

Alternative 4 provides an unclassified space on the upper floor through the construction of a secondary isolation wall offset from the shared digester wall. In this alternative, only the upper floor would be unclassified. The construction of walls on the lower floor is not possible due to space constraints. The unclassified classification is necessary on the upper floor so that the boilers can be installed in the existing space. Walls would also have to be constructed to block off shared atmospheric spaces with other parts of Building 3, because of this, a door and platform would be installed off the 2nd floor as a point of access for egress and equipment. The isolation wall has been spaced 4 feet off the digester wall in order to provide an access corridor around the isolated portion of the upper floor. The ACH and LEL/H2S gas detection equipment improvements described in Alternative 2 would also be implemented. HVAC needs in the unclassified portion of the building would have reduced demands and would consist of supply and exhaust fans and louvers. Equipment installed on the lower level would be CID2 and equipment upstairs would be unclassified. A layout of Alternative 4 is shown in Figure 4-4. A larger copy of the layout is located in Appendix A2.

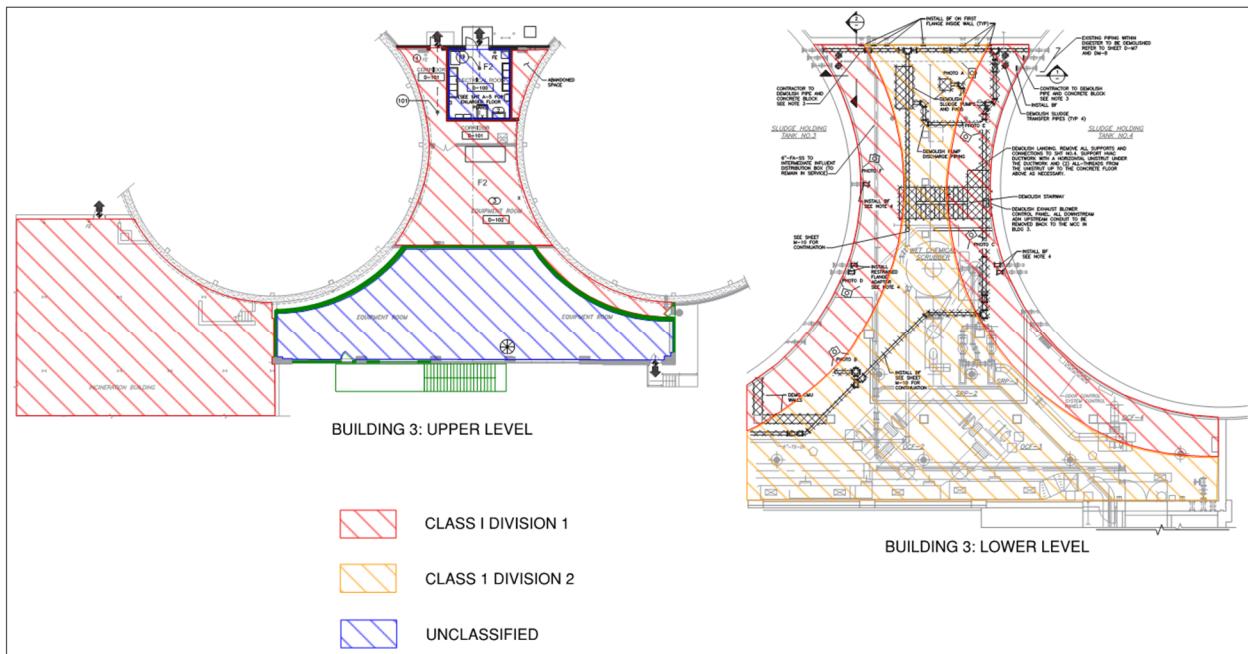


Figure 4-4: Space Classification Alternative 4

4.11 Plant Utility Demands

4.11.1 Natural Gas

During the Nelson Facility Plan, contact was made with Kansas Gas Service. They confirmed that the only improvement needed to allow them to meet peak gas demand, estimated at 22,000 CFH, would be to extend a 4-inch main from the southeast corner of the site to approximately the north Nall Avenue plant entrance.

4.11.2 Electrical

The Main Switchgear that feeds MCC-7003 and MCC-7009 has a Main-Tie-Main configuration fed from two KCPL transformers rated 1000kVA each. The maximum KVA rating for Bus A over the

previous one year period was approximately 450kVA. The maximum KVA rating for Bus B over the previous one year period was approximately 125kVA. The anticipated running load being added as a part of this project is approximately 200kVA. The KCPL transformers and Main Switchgear are adequately sized to accommodate the new loads.

4.12 Probable Cost Summary

A breakdown of the Building 3, Digester, and Flare probable costs is shown in Table 4-7. Please note that a second, backup boiler has been included based upon the BODR Workshop on 7/25/19.

Table 4-7: Building 3, Digester, and Flare Probable Costs

Base Scope¹

Building/Structure	\$401,000
Equipment & Piping ²	\$2,440,000
Electrical/I&C	\$101,000
Related Work Allowances	\$715,000
Subtotal:	\$3,657,000
Allowances & Markups ³	\$2,419,000
Total Construction Cost	\$6,075,000
Engineering, Legal, Admin (27.5%)	\$1,671,000
Total Cost	\$7,746,000

¹ Based on Space Classification Scenario 4 - Barrier walls

² Includes Two Boilers as Discussed at BODR Workshop 7/25/19

³ Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

Potential Adders (Total Costs)

Redundancy in Primary Digestion	\$1,178,000
Digester Coating in Lieu of Barrier Walls	\$796,000

Potential Deducts (Total Costs)

Odor Control Improvements (including Chemical Room)	\$608,000
HVAC (Provide Minimal HVAC on upper floor in Scen 4.)	\$184,000

4.13 Hot Water System Housing Alternative – New Digester Equipment Building

4.13.1 General

Due to NFPA code declassification concerns of maintaining a declassified space for the boiler equipment within the upper level of Building 3, an alternative was discussed for installing the boilers, heat exchangers, and loop pumps in a new digester equipment building located north of Building 3. This alternative would be configured so that the building could be expanded to house the equipment that would be added under future phases, as shown in Figure 4-5. The new building would consist of two separate spaces. The space to the northwest would contain the boiler equipment and the adjacent space would contain the hot water loop pumps and heat exchanger as shown in Figure 4-6. The new equipment building would only house the items that were proposed to be located on the upper level of Building 3. The sludge heating pumps and jet mixing pumps will remain on the lower level of Building 3. The boiler room will have man door access and removable louvers for equipment access. The heat exchanger area will have a roll up door for equipment installation and removal as well as man door access. Access will be maintained to the existing electrical room through the new building space.

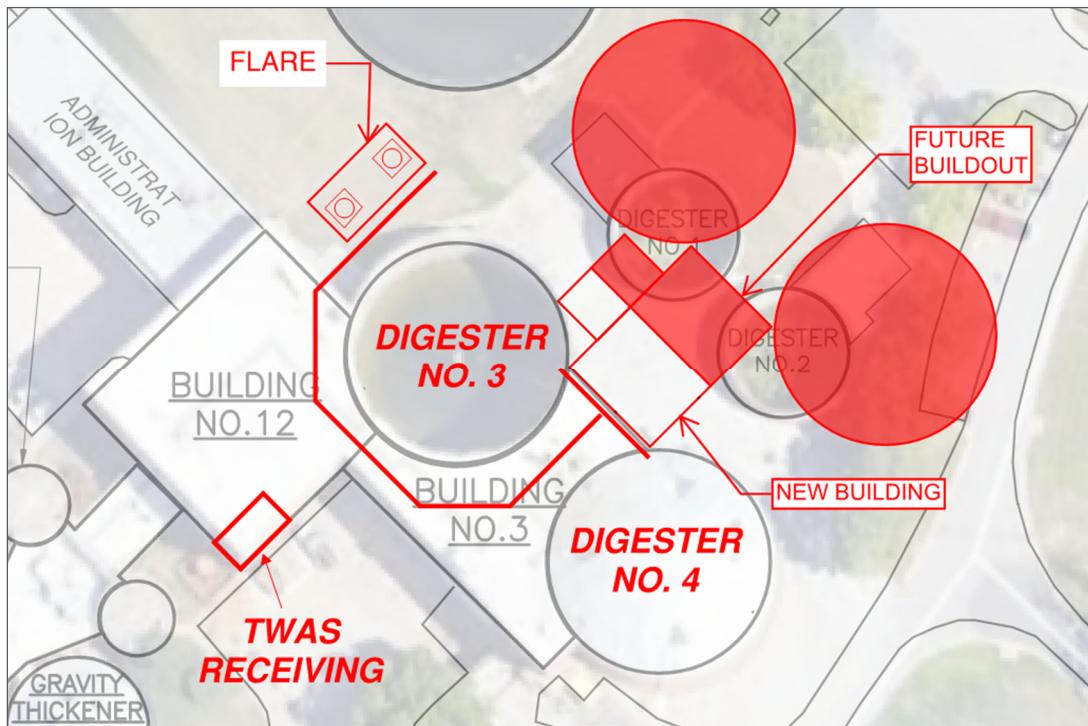


Figure 4-5: New Digester Equipment Building Location

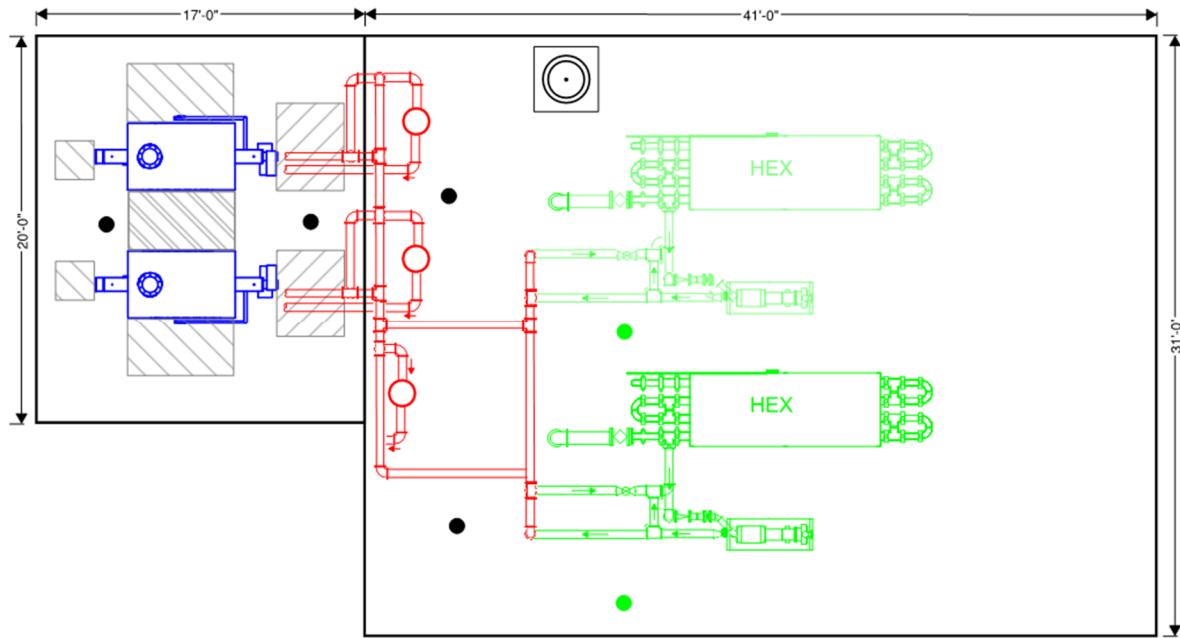


Figure 4-6: Digester Building Equipment Layout

4.13.2 Process Mechanical

The new Digester Building will consist of the same equipment required if the upper floor of Building 3 is reused. A detailed discussion of the function of each piece of equipment can be found in Section 4.3. The sludge mixing pumps and sludge heating pumps will remain in the lower level of Building 3. The new building will allow for an equipment layout that provides adequate space between the equipment for maintenance activities, as well as provides sufficient access for equipment removal. The boilers will be located in a separate room to allow for declassification of the space per NFPA. Louvers will be provided in front of each boiler to allow for natural ventilation of the space as well as providing a means for equipment removal. Access will be maintained to the existing electrical room by providing a pathway from the east side of the new building to the existing electrical room door.

4.13.3 Structural

Due to the proximity of the surrounding buildings and structures, it is recommended that the new digester equipment building be constructed on piers, similar to the adjacent buildings.

4.13.4 Electrical

The new building would utilize MCC-7003, located in the Building 3 Electrical Room. The electrical room requirements and improvements would be the same as those described in Section 4.8.

4.13.5 Instrumentation

The Allen-Bradley ControlLogix PLC is located in LCP-7003, located in the Building 3 Electrical room, has adequate spare slots to add new cards for the I/O anticipated for this project, therefore a new PLC is not anticipated. The instrumentation improvements would be the same as those described in Section 4.9.

4.13.6 Probable Cost

A breakdown of the new digester equipment building is shown in Table 4-8. Please note that this estimate includes some necessary upgrades to Building 3 such as combustible gas detection,

various pumps, piping, and chemical room improvements, in addition to the new building and its associated equipment.

Table 4-8: New Digester Building Alternative Probable Cost

Base Scope¹

Building/Structure	\$814,000
Equipment & Piping ²	\$2,387,000
Electrical/I&C	\$119,000
Related Work Allowances	\$816,000
Demolition of Existing Digesters 1 and 2	\$220,000
Subtotal:	\$4,356,000
Allowances & Markups ³	\$2,881,000
Total Construction Cost	\$7,237,000
Engineering, Legal, Admin (27.5%)	\$1,990,000
Total Cost	\$9,227,000

¹ Includes Building 3 Equipment, New Digester Building, Flare, and Chemical Room Improvements

² Includes Two Boilers as Discussed at BODR Workshop 7/25/19

³ Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

4.14 Comparison of Digester Equipment Building Alternatives

Table 4-9 has a list of the benefits and negatives reusing the upper floor of Building 3 to house the digester heating equipment. Table 4-10 has a list of the benefits and negatives of constructing a new digester equipment building which will be expanded in future project phases.

Table 4-9: Reuse of Building 3 Upper Level Pros and Cons

Reuse of Building 3 Upper Level	
Pro	Con
Existing space with building shell already in place	Requires stair tower for ingress and egress to the space
Capital cost are lower than a new building	Will require equipment to be removed from a second story (elevated) "loading dock"
	If equipment is not relocated when future digester control building is constructed, then there will be similar equipment located in two separate spaces
	If equipment is relocated to the future building, will require extended shut downs and equipment to be offline during construction

Table 4-10: New Digester Control Building Pros and Cons

New Digester Control Building	
Pro	Con
Allows for separation and declassification of a dedicated boiler room. Room layout will be based on required access and maintenance for the boilers	Additional Cost in Phase 1A with potential cost savings when future digester control building is constructed.
Does not require future removal or relocation of Phase 1A equipment when future Digesters and Digester Control Building are constructed in the BNR Project	Construction of new facility may require shoring to protect from adjacent facilities
Capital costs are going towards a new facility that can be integrated into the BNR project. If the upper level of Building 3 is used, that capital investment may only last approximately 10 years if the BNR project relocates	Facility will need to be designed and constructed to accommodate future BNR project design. All detailed design components, equipment, etc. are not finalized so assumptions need to be made to accommodate future equipment and tie into planned structure
Better arrangement for equipment access for maintenance and for equipment removal	

Table 4-11 has a side by side probable cost comparison of both digester equipment building options.

Table 4-11: Digester Equipment Building Alternatives

Digester Equipment Building Alternative*	Total Cost	Cost Difference
Alternative 4: Building 3 w/ Isolation Wall	\$7,746,000	Base Case
New Digester Equipment Building	\$9,227,000	\$1,481,000

* Includes all markups

4.15 Proposed Solutions and Decisions

4.15.1 Sludge Digester Facility

- Digester 3 will be a primary digester and Digester 4 will be a secondary digester.
- Equipment layouts will consider the future upgrade to give both Digesters primary digester capabilities and allow easy addition to the configuration.
- New HVAC improvements will provide 12 air changes per hour will be added to the lower level of Building 3 to give it a C1D2 space rating, with the exception of a 5 foot envelope around the digester walls which will remain C1D1.

4.15.2 Digester Heating Equipment Room Classification

- Selected Alternative 4, the installation of isolation walls, for space classification on the upper floor of Building 3.
- Install two boilers
- Provided 4 feet of clearance around both digesters for plant operator access to other areas.
- An exterior stair tower from the ground level to the roof for egress.
- See Figure 0-3 in the Executive Summary.

4.15.3 Odor Control Improvements

- The chemical feed pumps will be replaced.

- The scrubber, recirculation pumps, and duct will remain as is. These items will be replaced as needed in the future in the event of failure.

4.15.4 Chemical Storage Room

- The relocation of the Sodium Hypochlorite storage tank and filling receptacle was discussed, due to the infrequency of filling and difficulty locating an accessible location.
- For code compliance, the door to the room will be replaced with a 3-hour fire rated door.
- See Figure 0-4 in the Executive Summary.

4.15.5 Waste Gas Flare

- Install a mowstrip installed gas piping to reduce ground keeping maintenance.
- Include tees on the gas piping in strategic locations for the future relocation of the flare pad.
- Placed near the middle of the plant to reduce noise broadcasted to nearby neighbors.
- This is a temporary location, a more suitable final location will be determined once the future Nelson WWTF rebuild project has reached its final design iteration.
- See Figure 0-5 in the Executive Summary.

4.15.6 30% Cost Estimate for Building 3, Chemical Room, and Waste Gas Flare Improvements

The updated 30% Design cost estimate for the Building 3, Chemical Storage Room, and Waste Gas Flare Improvements is shown below:

Digester Facility: Building 3, Flares, Chemical Storage Room	
Building/Structure	\$360,000
Equipment & Piping	\$2,684,000
Electrical/I&C	\$101,000
Related Work Allowances	\$572,000
Subtotal:	\$3,717,000
Allowances & Markups ¹	\$2,458,000
Total Construction Cost	\$6,175,000
Engineering, Legal, Admin (27.5%)	\$1,698,000
Total Cost	\$7,874,000

¹ Includes Contractor Markups (22%), Contingency (30%), Escalation (3.5%)

5 Impact on Dewatering and Other Operational Considerations

The Phase 1A Project will provide anaerobic digestion and stabilization of the Nelson Complex produced solids and trucked-in TWAS solids. This material will have properties and characteristics different than the raw sludge that is currently dewatered with centrifuges prior to landfilling. This section will review potential impacts on the dewatering operations.

5.1 Impacts on Centrifuge Operation

The future sludge production for flow and loads based on Pro2D2 modeling of the new reference BNR process is shown in Section 2.3. It includes a range of sludge production based on high and lower non-biodegradable fractions. As noted in Section 1, the supplemental influent sampling completed as part of model calibration in the 2019 Nelson Complex WWTF Facility Plan suggested that the influent non-biodegradable volatile suspended solids (VSS) fraction of the influent wastewater characterization could be higher than typical domestic wastewater. The non-biodegradable VSS fraction is a characteristic that will impact solids dewatering. The volatile solids reduction for the average day sludge production condition was assumed to be 50%, while the volatile solids reduction for the maximum month sludge production condition was assumed to be 40%. The amount of solids mass that will be pumped to the centrifuges will be increased based on future increased flow and loads but also decreased with the addition of anaerobic digestion. The centrifuge feed solids concentration after anaerobic digestion will be more dilute.

The current and projected future centrifuge performance of the centrifuges at the Nelson Complex are summarized in Table 5-1.

Table 5-1: Current and Predicted Future Centrifuge Performance

Parameter	Current Centrifuge Performance (average day condition with lower non-bio VSS)	Current Centrifuge Performance (Maximum Month condition with higher non-bio VSS)	Future Estimated Centrifuge Performance (Average Day Sludge condition with lower non-bio VSS)	Future Estimated Centrifuge Performance (Maximum Month Condition with higher non-bio VSS)
Solids Loading (lbs/day)	28,805	39,932	28,803	43,503
Hydraulic Loading (gpd)	119,032	147,751	136,280	173,551
Feed Total Solids Concentration	2.9	3.2	2.5	3.0
Feed Volatile Solids Concentration (%)	74-80 (Avg 77)	74-80 (Avg 77)	70	71
Cake Solids Concentration (%)	22-30 (Avg 26)	22-30 (Avg 26)	23	21
Dry Polymer Dose (lbs/DT)	15	15	20	25
Hydraulic Loading Rate (gpm) @ average feed solids concentration	275	300	250	275
Solids Loading Rate (lbs/hr)	4,800	5,250	3,400	3,750
Operation (days per week)	5	5	5	5
Operation (hours per day)	6.6	8.2	9.1	10.5
Density (lbs/cu ft)	60	60	60	60
Dewatered Cake Volume (cubic yards per day)	68	95	77	128
Truck Trips @ 25 cubic yards per truck	2.7	3.8	3.1	5.1

Typically, raw sludge generated by primary clarifiers and the trickling filter processes dewater better than digested biosolids generated by primary clarifiers and the activated sludge processes based on centrifuge performance information at WWTPs across the United States. Therefore, the cake solids from the centrifuges at the Nelson Complex is estimated to decrease from an average of 26 to a range of 21 to 23. The centrifuges are estimated to require more polymer to dewater the future biosolids and increase from 15 to a range of 20-25 lbs/dry ton. The capacity of the existing dry polymer system is sufficient for the maximum month sludge production condition.

The centrifuge hydraulic and solids loading rates will decrease based on pumping a more (approximately 30% solids) dilute feed solids concentration that results from anaerobic digestion. For example, the solids loading rate will decrease from approximately 5,250 lbs/hr to 3,750 lbs/hr and the hydraulic loading rate will decrease from approximately 300 to 275 gpm on a maximum month sludge production basis. This will result in an increase in operation from 6.6 to 9.1 hours per day (hpd) at average day sludge production and an increase from 8.2 to 10.5 hpd operation at maximum month sludge production assuming one centrifuge in operation and 5 day-per-week operations. The centrifuge sludge are equipped with VFDs and can provide enough turndown to accommodate the lower centrifuge hydraulic loading rate.

The dewatered biosolids cake concentration is estimated to be approximately 23 percent at average annual sludge production compared to 26 percent now. Therefore, the dewatered cake volume will be somewhat higher. However, fewer biosolids will be produced after anaerobic digestion.

Therefore, the number of truck trips will increase from 2.7 (68 cu yd) to 3.1 (95 cu yd) at average day conditions and increase from 3.8 (77 cu yd) to 5.1 (128 cu yd) at maximum month conditions at 25 cubic yard capacity per truck).

5.2 Centrifuge Building Equipment Evaluation

Secondary Digester No. 4 has approximately 72 hours or 3 days of storage at the current centrifuge hydraulic feed rate of 300 gpm. This allows for 5 day-per-week operations and storage on the weekends with one extra day of storage. The estimated future storage time in Digester No. 4 will increase to 86 hours assuming a future centrifuge hydraulic loading rate of 250 gpm. The capacity of the Secondary Digester No. 4 is adequate.

The existing Humboldt (now serviced by Andritz) Decanter Model CP4-1.1, Type MX centrifuges have adequate capacity (300 gpm) and the bowl size, speed, and torque are acceptable for dewatering digested biosolids as well as raw sludge. It is our understanding that both units are operating well and that both of the bowls have been recently been refurbished. However, the bowl weir depth will probably need to be lowered and the differential speed needs to be adjusted to provide a higher detention time in the centrifuge to dewater the more dilute digested biosolids.

The recommended operational and minor capital improvements to the centrifuge dewatering facilities include:

- Adjust centrifuge weir depth and operational differential speed

5.3 Struvite Control

High concentrations of nitrogen, phosphorus, and trace metals are released in anaerobic digestion. The release of these components creates a possibility of nuisance precipitation formation in anaerobic digestion and dewatering. Struvite ($MgNH_4PO_4$) is the most commonly observed nuisance precipitate. The most common locations for detrimental struvite formation and deposition are:

- Areas associated with pH increases, which primarily includes aerobic sludge holding tanks and dewatering equipment. In digestion and post-digestion systems, precipitated struvite is often in equilibrium with the solution, which limits the deposition of struvite. With local pH increases, the equilibrium point changes resulting in increases struvite precipitation and typically deposition. Generally, the pH increases near 0.5 standard units through dewatering, causing deposition on dewatering equipment.
- Locations with high liquids shear, which includes submersible mixers, piping elbows and tees, and mixing nozzles.
- Locations associated with rapid temperature changes, such as heat exchanging equipment.
- While struvite formation occurs within the solids stream (e.g. digester, sludge holding tanks), detrimental formation tends to occur in areas with low solids concentrations such as centrate hoppers, belt press drip trays, dewatering belts, and dewatering conveyance systems.

Common forms of struvite mitigation include:

- Metal salt addition, which can either target binding available phosphate or be used to limit the rise in pH observed in dewatering.
- Polymer addition. De-nucleation polymers prevent struvite precipitation.
- Centrate dilution with a low pH water source, such as secondary effluent or scrubber water.
- Post aerobic digestion/sludge holding. Aerated sludge holding induces precipitation by stripping carbon dioxide, which increases the pH. Struvite formation will increase, but it will occur in a high solids environment which typically results in struvite forming within the solids matrix rather than depositing on equipment and piping.
- Targeted struvite formation through nutrient recovery.

While detrimental struvite formation can be problematic at any WWTF, incorporation of enhanced biological phosphorus removal in the activated sludge process significantly increases the amount of phosphorus released and subsequent struvite production. Generally, incorporation of biological phosphorus removal increases the precipitation potential by 200 to 300%. During Phase 1 of the solids process expansion, the primary sludges fed to the digesters will be sludges from non-biological phosphorus removal facilities. During this period, detrimental struvite production will likely be limited to dewatering equipment associated with pH increases. As such, the recommended struvite mitigation strategy is to utilize ferric chloride to prevent increases in pH from occurring in dewatering.

Struvite mitigation should be revisited during the design of the Nelson Complex biological nutrient removal expansion

5.4 External Impacts

5.4.1 Landfill Backup

In the event that the Phase 1A digesters go offline for maintenance or due to an upset, JCW would like to retain landfill disposal through Waste Management as a secondary method for solids disposal for the Nelson Complex. Initial conversations between JCW and Waste Management have indicated that it is likely that such an arrangement can be accommodated.

5.4.2 Land Application Contractor

JCW recently completed a solicitation for a land application contractor to provide services for the hauling and land application of biosolids. This solicitation included provisions to add the Phase 1A biosolids when the facilities go into operation.

5.4.3 JCW TWAS Haulers

The accessibility of the new TWAS receiving station was an important factor in its layout. The facility was designed to accommodate multiple haulers simultaneously and still provide sufficient space for vehicle turning movements. The proposed layout was discussed with several TWAS haulers at the Nelson Complex and it was confirmed that these objectives were met.

5.4.4 Laboratory Needs

Several measurements and laboratory tests need to be conducted regularly to accurately monitor the performance of the digesters. Understanding the importance of each of these measurements and tests allows the operations staff to detect operating problems before they can seriously affect

digestion performance. A list of recommended tests follows and a more detailed discussion of each test is included in Appendix B.

- Temperature
- Ammonia
- pH
- Alkalinity
- Volatile Fatty Acids
- Volatile Acid-Alkalinity Ratio
- Volatile Solids
- Chemical Oxygen Demand
- Gas Production
- Biogas Content

6 Project Summary and Implementation Plan

6.1 Project Probable Cost Estimate

A breakdown of the total project probable costs is shown in Table 6-1. Various cost adders and deducts are shown for the different options discussed throughout this report.

Table 6-1: Project Probable Cost Estimate

Base Scope ¹	
Project Area	Construction Cost
TWAS Receivng	\$412,000
Building 9: Sludge Blending and Transfer Pumping	\$937,000
Building 3: Digester 3 Primary, Digester 4 Secondary, Backup Boiler, Dual Flares, Chemical Storage and Feed Improvements	\$6,075,000
Subtotal Construction Cost:	\$7,424,000
Engineering, Legal, Administration (27.5%):	\$2,042,000
Total Cost:	\$9,466,000

¹ Based on Blend Tank Mechanical Mixers and Space Classification Scenario 4 - Barrier walls

Potential Adders (Total Costs)

Hydraulic Mixing	\$36,000
Linear Motion Mixing	\$481,000
Redundancy in Primary Digestion	\$1,178,000
Digester Coating in Lieu of Barrier Walls	\$796,000
New Digester Heating Equipment Building	\$1,481,000

Potential Deducts (Total Costs)

Delaminated Pipe and Centrifuge Pump Replacement	\$325,000
Odor Control Improvements	\$608,000
HVAC (Provide Minimal HVAC on upper floor in Scen 4.)	\$184,000
Market Volatility Risk Factor	10%

6.2 Project Schedule

Table 6-2 shows the anticipated project schedule for the remainder of the design phase, advertisement, bid, and award, and construction. Construction phase for this project is expected to take a year to complete.

Table 6-2: Project Schedule

ITEMS	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	Jul 20	Aug 20
Design - 30%											
Design - 60%											
Design - 90%											
Final Design											
Advertisement, Bid, and Award											
Construction											

6.3 Permitting

The following permits governing the facility, the construction process, and ongoing site utilization are required:

- City of Mission - Building Permit
- KDHE - Construction Permit

A Kansas General Permit for Stormwater Runoff is not anticipated to be needed based upon the estimated area of disturbed land for current scope of work. Based upon the selections of the proposed improvement alternatives, a Preliminary Development Plan (PDP) or Final Development Plan (FDP) may be required. This will be determined through a discussion with the City of Mission after all alternative selections have been made.

During construction, the Contractor will be required to obtain the following:

- Hot Work Permit
- Business Occupational License - City of Mission
- Sign Permit - City of Mission

APPENDIX A

DISCIPLINE DESIGN CRITERIA

APPENDIX A1

STRUCTURAL

1. Structural Design Codes and Standards

International Building Code 2012. See City of Mission Community Development site,
<http://www.missionks.org/pView.aspx?id=17589&catid=657>.

ACI 350-05 Code requirements for Environmental Engineering Concrete Structures and Commentary.

ACI 318-05 Building Code Requirements for Structural Concrete and Commentary.

ACI 530-05/ASCE 5-05/TMS 402-05 Building Code Requirements for Masonry Structures.

AISC Manual of Steel Construction, 13th Edition.

AA ADM 1-00 Aluminum Design Manual.

ASCE 7-10 Minimum Design Loads for Buildings and Other Structures.

2. Loads

Structural design loads are generally defined in the Standards. The following provides additional, project-specific clarification of the loads. Where conflicts exist between the Building Code and this document, the more stringent requirements shall apply. Structures for this project will be classified in accordance with IBC table 1604.5 as Occupancy Category III (wastewater treatment plants). Design loads will be noted on the drawings as required by the Building Code.

2.1. Dead Load

Dead load will be the weight of materials of construction incorporated into the structure, including but not limited to walls, floors, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items.

2.2. Live Load

Floor live loads will be in accordance with the building code but typically not less than 100 psf. Live loads will be increased where necessary for the use of the structure.

Process Areas and Electrical Rooms:	200 psf
Water containing structures:	Actual head, 300 psf min
Stairs and Landings:	100 psf
Equipment Platforms and Walkways:	100 psf

2.3. Piping

Smaller pipes less than 10 IN in diameter will be accounted for in a uniform piping load. The uniform load will be evaluated after preliminary piping layouts are known, and will be no less than 10 psf. Pipes 10 IN and larger, pipe racks and piping valves produce heavier concentrated loads at the pipe hangers. Pipe support reactions for larger pipes will be calculated and structural members will be designed for the appropriate loads.

2.4. Equipment

Approximate size and weight of equipment will be used in structural design where multiple vendors may supply the specified equipment. The weights of smaller equipment may be

included as part of the design live load if the equipment plus equipment pad weight is less than the design live load. Localized areas of the structure will be designed to provide support for larger pieces of equipment in addition to the other uniform loads when the average distributed equipment load is greater than the design live load. Include equipment pad weights with the equipment weight. Dynamic loads will be included when appropriate.

2.5. Fluid Loads

Lateral and vertical loads from fluid applied loads will be considered in analyzing digester capacity. The specific gravity of the fluid will be taken as 1.0 for wastewater, mixed liquor, and sludge. The design high water level elevation will be in accordance with the digester process design.

Structural design for lateral groundwater pressure will be based on saturated soils below the elevation of the building foundation drain.

2.6. Snow Load (ASCE 7-05)

Ground Snow Load, $P_g = 20 \text{ psf}$ (IBC Figure 1608.2)

Exposure Factor, $C_e = 1.0$ (Based on Table 7-2, Exposure Category C, Partially Exposed)

Thermal Factor, $C_t = 1.0$ (Based on Table 7-3)

Importance Factor, $I_s = 1.1$ (Based on Table 7-4)

Drifting snow and roof projections will be considered.

2.7. Roof Live Load

A minimum roof live load of 20 psf will be used. No reductions will be used for tributary area or roof slope.

2.8. Wind Load (ASCE 7-11)

Ultimate Wind Speed = 120 mph.

Exposure Category C

Importance Factor, I_w is 1.00

The simplified provisions for low-rise buildings (per IBC) will be used.

2.9. Seismic Load

Spectral response accelerations: $S_s=0.112g$; $S_1=0.064g$.

Site Class D, stiff soil.

Seismic design category and Importance Factor, $I_E = 1.25$.

2.10. Soil Load

Lateral Pressure: Lateral pressure based upon the at-rest condition will be used for channels to minimize wall movement and the potential cracks.

A surcharge of 250 psf or a produced by an HS-20 wheel load will be included in the design lateral pressure.

2.11. Load Combinations

Building Code load combinations will be used in design.

Serviceability factors (per ACI 350) will be included with all water bearing structures. Water bearing structures will be checked for the following load combinations.

Full water level without serviceability factors.

Normal water level with serviceability factors.

Empty inside with soil and design groundwater outside.

Filled inside without soil or groundwater outside.

3. Foundations

Slab on grade and equipment pads will be placed on a 6 IN layer of compacted granular fill over low-volume-change natural material or compacted structural fill. Geotechnical recommendations will be obtained for new foundations if required.

4. Building Structural System

Building 3 has a cast-in-place concrete frames and concrete slabs in the digester equipment area. The concrete floor and roof beams are supported on corbels at the digester walls so that movement of the walls and slab are independent. The building has masonry infill walls with clay brick and glazed clay interior masonry units. The digesters are concrete tanks with clay brick veneer.

Structural modifications to Building 3 may include new concrete masonry unit separation walls. The walls will be self-supporting, but will not be designed to affect the vertical or lateral load capacity of the existing building. If the weight of the walls exceeds the capacity of the existing cast in place concrete floor beams and columns, additional columns will be placed to carry the new wall load.

5. Structural Materials

5.1. General Use Concrete

Minimum 28-day compressive strength, $f'_c = 4500$ psi

Maximum w/c = 0.42

Portland cement will be Type II. Concrete for water retaining structures will not include fly ash. Ground slag may be incorporated in concrete mix designs.

Suitable for concrete exposed to freeze / thaw in moist condition

Suitable for concrete subjected to moderate sulfate exposure.

5.2. Concrete Topping

Minimum 28-day compressive strength, $f'_c = 4000$ psi

Maximum w/c = 0.45

Modifications to maximum aggregate size

Include polypropylene fibers

5.3. Reinforcing Steel

ASTM A516 Grade 60

Minimum yield strength, $f_y = 60,000 \text{ psi}$

5.4. Masonry

Compressive Strength, $f'm = 1500 \text{ psi}$, normal weight block with integral water repellent admixture for exterior masonry walls. All exterior masonry wall mortar will have integral water repellent admixture as well.

Interior walls lightweight concrete masonry units.

Control joints at 20 FT, or conforming to building layout.

5.5. Steel

The following materials will be used as the default steel in the specifications. Other grades of steel may be used under certain conditions. However, these different grades of steel need to be specified and the specific locations must be indicated on the Drawings.

W and WT shapes: ASTM A992 (Grade 50)

Other shapes and plates: ASTM A36 ($F_y = 36 \text{ ksi}$)

Pipes: ASTM A53 Grade B ($F_y = 35 \text{ ksi}$)

Hollow struct. sections (Rect.): ASTM A500, Grade B ($F_y = 46 \text{ psi}$)

High strength bolts: ASTM A325

All steel will be hot-dip galvanized.

5.6. Anchor Bolts

Type 316 Stainless Steel.

5.7. Stainless Steel

Type 304 or 316 Stainless Steel.

5.8. Aluminum

The following materials will be used as the default aluminum material in the specifications. Other alloys may be used under certain conditions. However, these different alloys need to be specified and the specific locations must be indicated on the Drawings.

Alloy 6061-T6, $f_y = 32,000 \text{ psi}$

Bolts: ASTM F467 and F468, Alloy 2024 T4

Welds: AWS D1.2 filler alloy 4043 or 5356

5.9. Material Requirements for Corrosion Resistance

Structural steel: Hot-dip galvanized and finish painted.

Stairs, landings, and platforms (exterior, and process building interior): concrete or aluminum with aluminum grating treads and landings.

Ladders: Aluminum.

Channel grating: Aluminum bar grating, plank, or stiffened checkered plate.

Guardrail and handrail systems: Mill finish aluminum, 3-rail pipe with kick plate where required.

Submerged supports and components, including weirs and gates: Stainless steel.

Floor doors and access hatches: Aluminum with stainless steel hardware.

Anchor bolts: Stainless steel.

APPENDIX A2

ARCHITECTURAL

1. General Architectural Design Criteria

This appendix presents the architectural design criteria for the Biosolids Facilities Improvements at the Nelson Complex Wastewater Treatment Facility (Nelson WWTF). The information presented in this appendix includes the following:

- General Objectives and Scope
- Code Compliance Data
 - Governing Codes
 - Classifications and Allowances
- Architectural Design Issues
- Building Systems
 - Floors
 - Walls
 - Roof
 - Doors - Windows - Louvers

2. GENERAL OBJECTIVES AND SCOPE:

The architectural scope of the project includes reconfiguration of the digester control rooms, chemical storage room and adjacent spaces in the existing Building 3. There is potential for a new digester control building to be constructed outside of the footprint of the existing building.

3. CODE COMPLIANCE DATA

3.1. GOVERNING CODES

The design will be based on the 2012 edition (unless noted otherwise) of the following codes, as adopted and amended by the City of Mission:

- City of Mission Code of Regulations for Buildings and Construction, 2012 Edition
- International Building Code
- International Existing Building Code
- International Fire Code
- International Mechanical Code
- International Plumbing Code
- International Energy Conservation Code
- International Fuel Gas Code
- National Electrical Code (NEC) - 2011 Edition

3.2. CLASSIFICATIONS and ALLOWANCES

- Occupancy: Group F-2, Low Hazard, Factory-Industrial Occupancy (Section 306)
- Construction Type: Type II-B (Section 602)
- Area Allowance: 23,000 SF per floor (Section 503 and Table 503).
- Height Allowance: 3 stories, 55-feet (Section 504 and Table 503).

4. ARCHITECTURAL DESIGN ISSUES

The primary objective to successful building architecture at the Nelson WWTF is to facilitate future construction that follows the general brick veneer aesthetic, allowing variations based on building type and use.

5. BUILDING SYSTEMS

Building 3 has a cast-in-place concrete frames and concrete slabs in the digester equipment area. The building has masonry infill walls of glazed clay interior masonry units with clay brick veneer on the exterior. The digesters are concrete tanks with clay brick veneer.

Any new buildings and/or structures to be constructed as part of the Biosolids Facilities Improvements at the Nelson Complex Wastewater Treatment Facility (Nelson WWTF) are intended to present a unified visual aesthetic throughout the plant.

Floors - The building will be single-story. The floor system will consist of cast-in-place reinforced concrete slab on grade. The concrete floor surfaces will receive a clear sealer.

Walls - Wall systems will consist of rain screen cavity wall brick veneer, in color to match the existing structures, over continuous rigid insulation applied to load bearing masonry block (CMU).

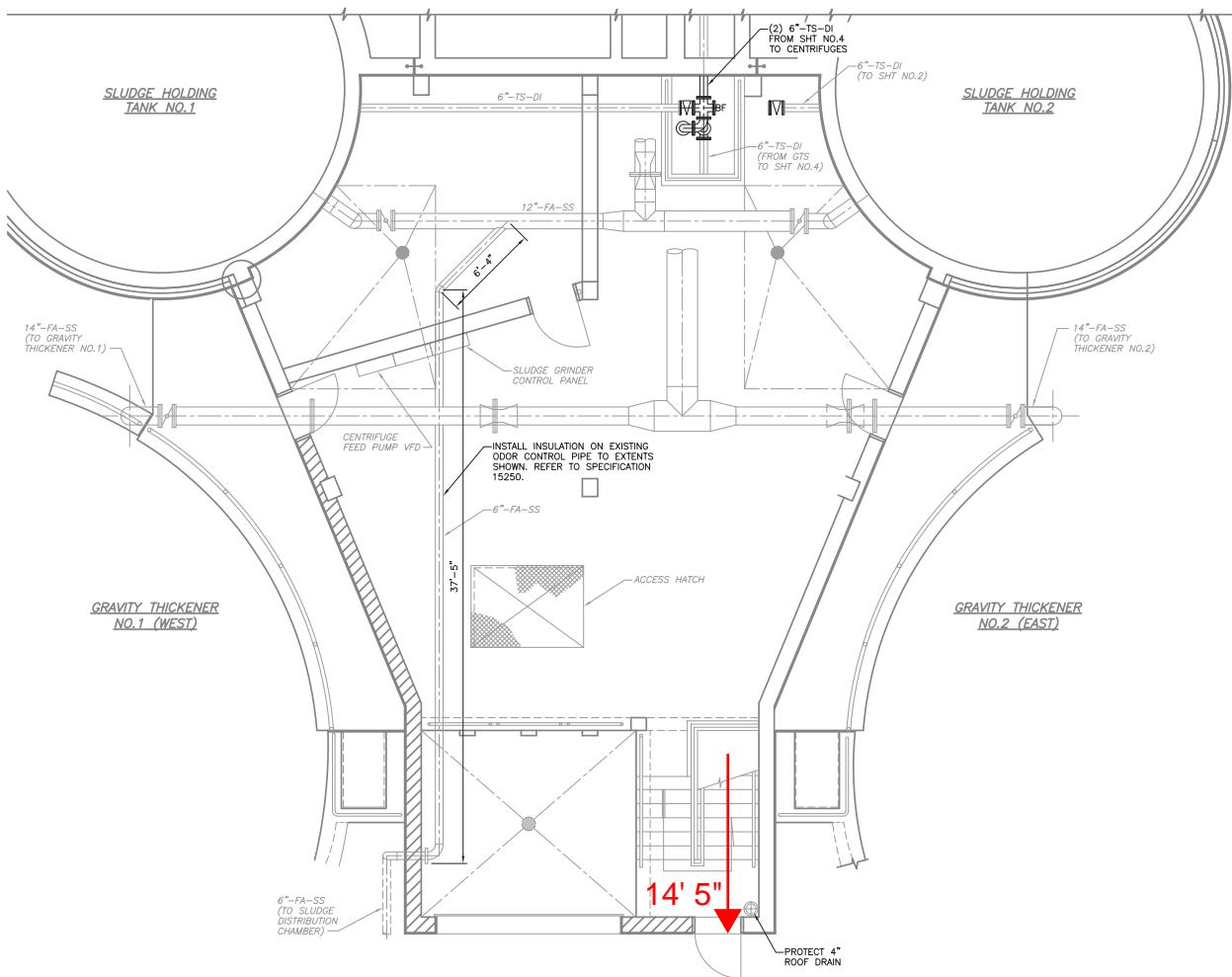
Roof - Roof systems will consist of a (nominally) flat single-ply PVC membrane roofing system over rigid insulation (sloped a minimum of 1/4-inch per foot) over the roof deck system. The roof deck will be determined by the Structural Engineer. Any steel framing will be coated with a high-build epoxy coating for corrosion resistance. The roof parapets will be capped with an aluminum coping system finished to match the existing structure and finished to resist corrosion.

Doors - Fire-rated doors and frames will be fiberglass reinforced plastic (FRP) in a galvanized hollow metal with a low maintenance epoxy painted finish. Where safety and/or visibility is required, the doors will have vision lites of up to 100 square inches. Door hardware (locksets, hinges, etc.) will be satin stainless steel for low maintenance and durability, keyed into the existing plant system. All other doors will be aluminum-FRP doors and frames, consistent with doors throughout the plant.

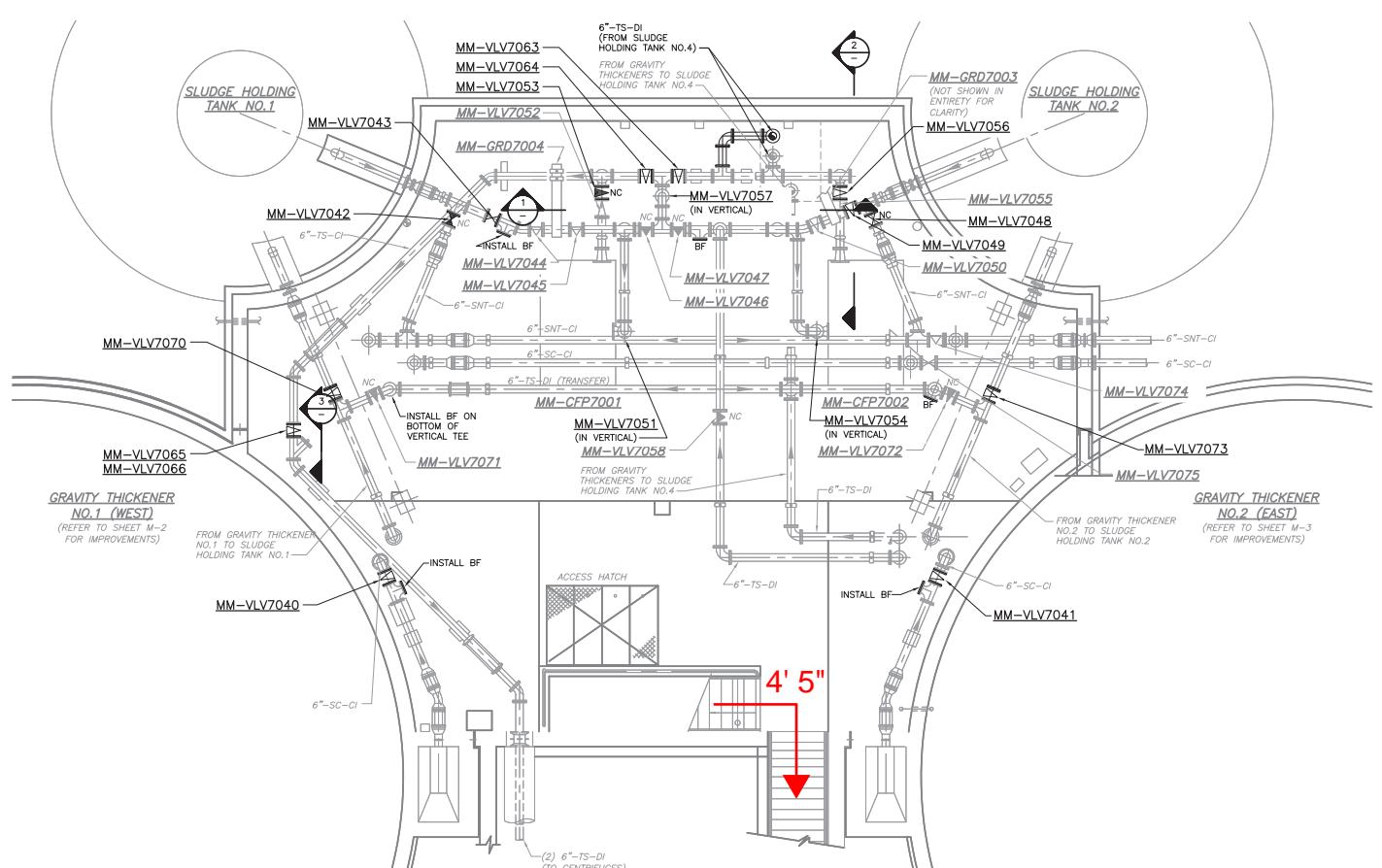
Windows - Windows will be insulated glass in fixed aluminum framing, providing insulated, low-maintenance natural light into the spaces they serve.

Louvers - Wall louvers will facilitate ventilation throughout the enclosed spaces in the building. They will be fixed aluminum, storm proof, and sized to maximize ventilation efficiency. Where not connected to ductwork, intake louvers will be equipped with bird screen, dampers and filter packs. Exhaust louvers will be equipped with insect screen and dampers. See the Mechanical appendix for further discussion.

JCW NELSON COMPLEX MISSION MAIN BUILDING 9 SPACE CLASSIFICATION



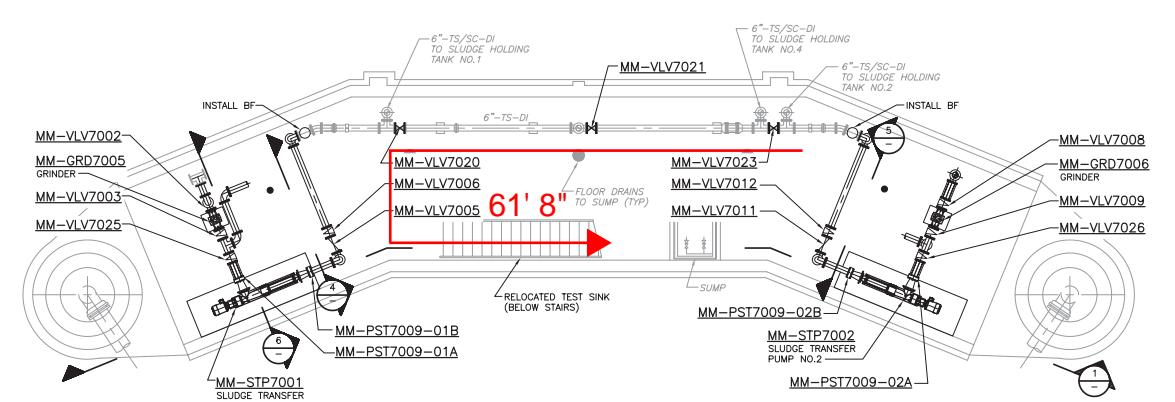
BUILDING 9: UPPER LEVEL



BUILDING 9: MIDDLE LEVEL

NOTES:

1. DUE TO THE VENTILATION INSTALLED THROUGH CONTRACT 20, BUILDING 9 IS UNCLASSIFIED.
 2. THE SPACE INSIDE THE GRAVITY THICKENERS AND SLUDGE HOLDING TANKS IS CLASS I DIVISION 1 (CID1).
 3. THE COMMON PATH OF EGRESS TRAVEL FROM THE LOWEST LEVEL IS 80' 6", WHICH EXCEEDS THE IBC 75' 0" LIMIT ALLOWED FOR A NON-SPRINKLERED GROUP F INDUSTRIAL OCCUPANCY. GIVEN THE FUTURE PLANS FOR THE COMPLEX, THE EXISTING NONCONFORMING CONDITION CAN LIKEY REMAIN.
 4. LOWER AND MIDDLE LEVELS CURRENTLY HAVE CGD/H2S DETECTION AND AUDIO/VISUAL NOTIFICATIONS, INSTALLED THROUGH CONTRACT 20. GAS DETECTION VENTILATION PANEL LOCATED AT SOUTH EXTERIOR DOOR ON UPPER 1 FVEI .



BUILDING 9: LOWER LEVEL



JACOBS

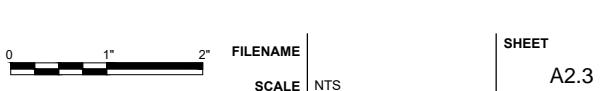
PROJECT MANAGER		
	CIVIL	
	STRUCTURAL	
	ARCHITECTURAL	
	PROCESS	
	MECHANICAL	
	ELECTRICAL	
	INSTRUMENTATION	
ISSUE	DATE	DESCRIPTION
PROJECT NUMBER	10052145	

**PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING**

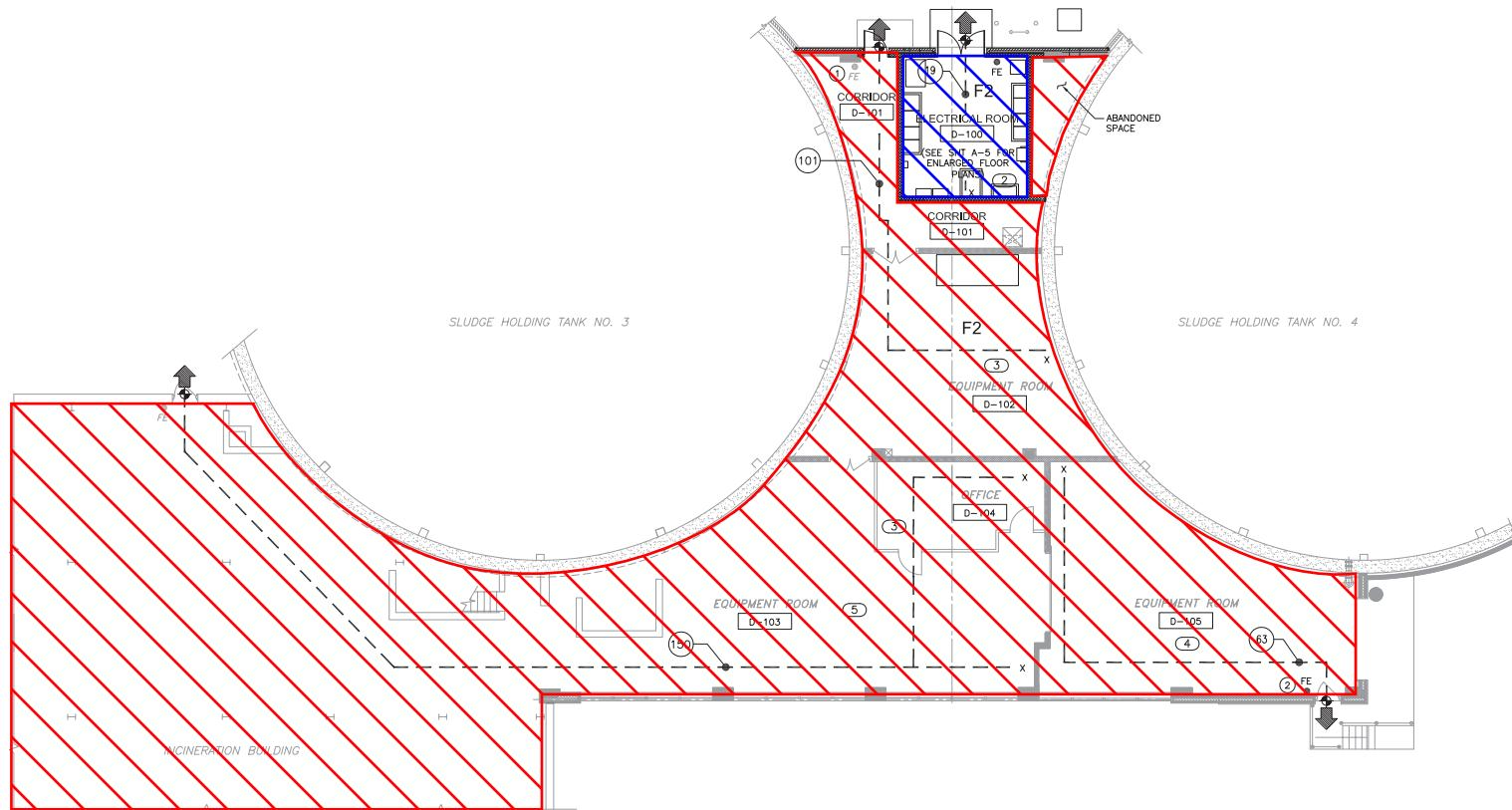


**NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028**

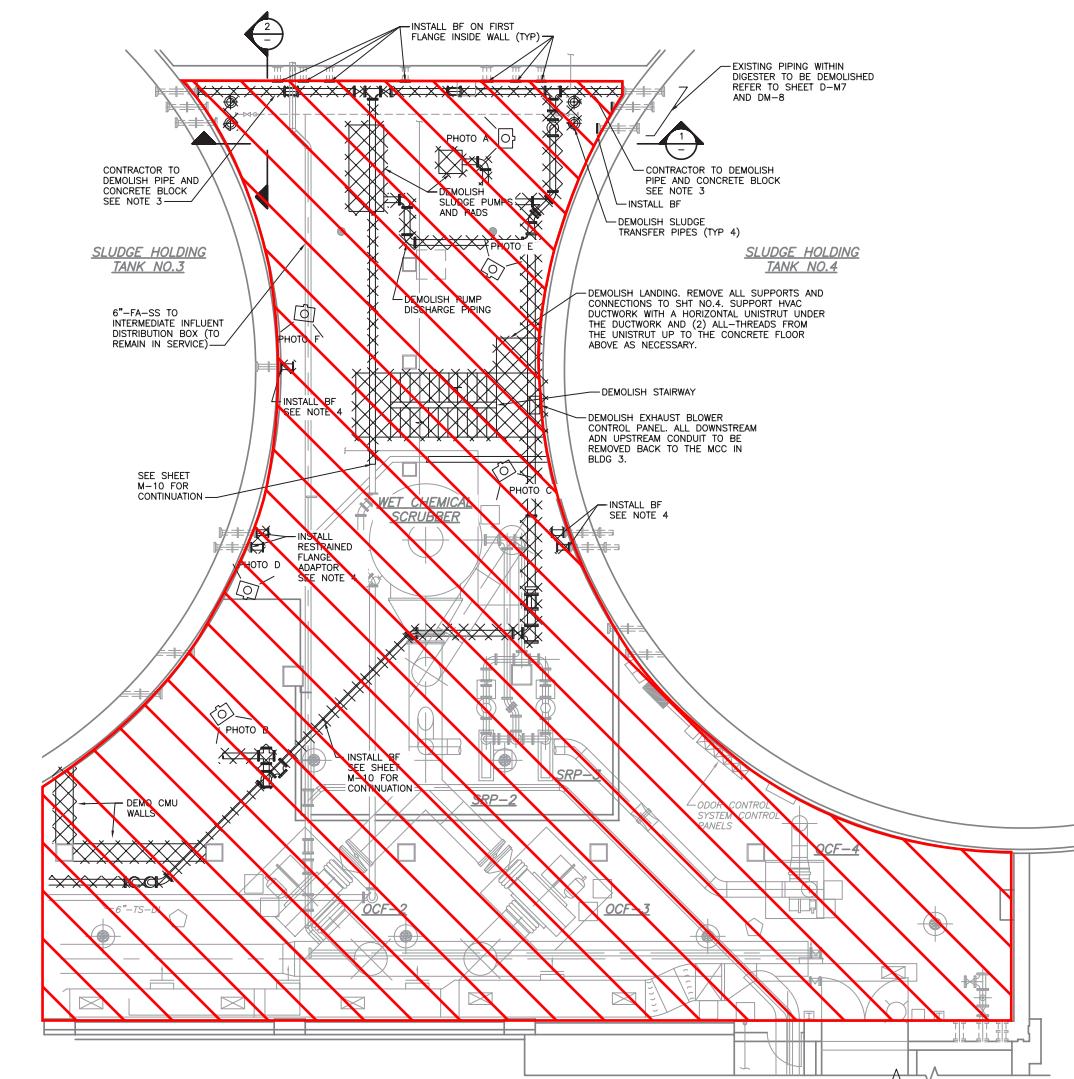
FIRE AND LIFE SAFETY: BUILDING 9



JCW NELSON COMPLEX MISSION MAIN BUILDING 3 SPACE CLASSIFICATION SCENARIO 1: EXISTING CONDITIONS



BUILDING 3: UPPER LEVEL



BUILDING 3: LOWER LEVEL

NOTES

1. AREA VENTILATION IS <12 ACH, ENTIRETY OF BUILDING 3 (AND ATMOSPHERICALLY CONNECTED SPACES) IS CLASS I DIVISION 1 (CID1).
 2. OFFICE ON UPPER FLOOR HAS COMBUSTIBLE CONSTRUCTION, RECOMMEND REMOVAL PER NFPA AND IBC.
 3. ELECTRICAL ROOM IS UNCLASIFIED DUE TO ISOLATION AND VENTILATION.
 4. EQUIPMENT IN LOWER LEVEL INSTALLED VIA CONTRACT 20 IS CID1 RATED.

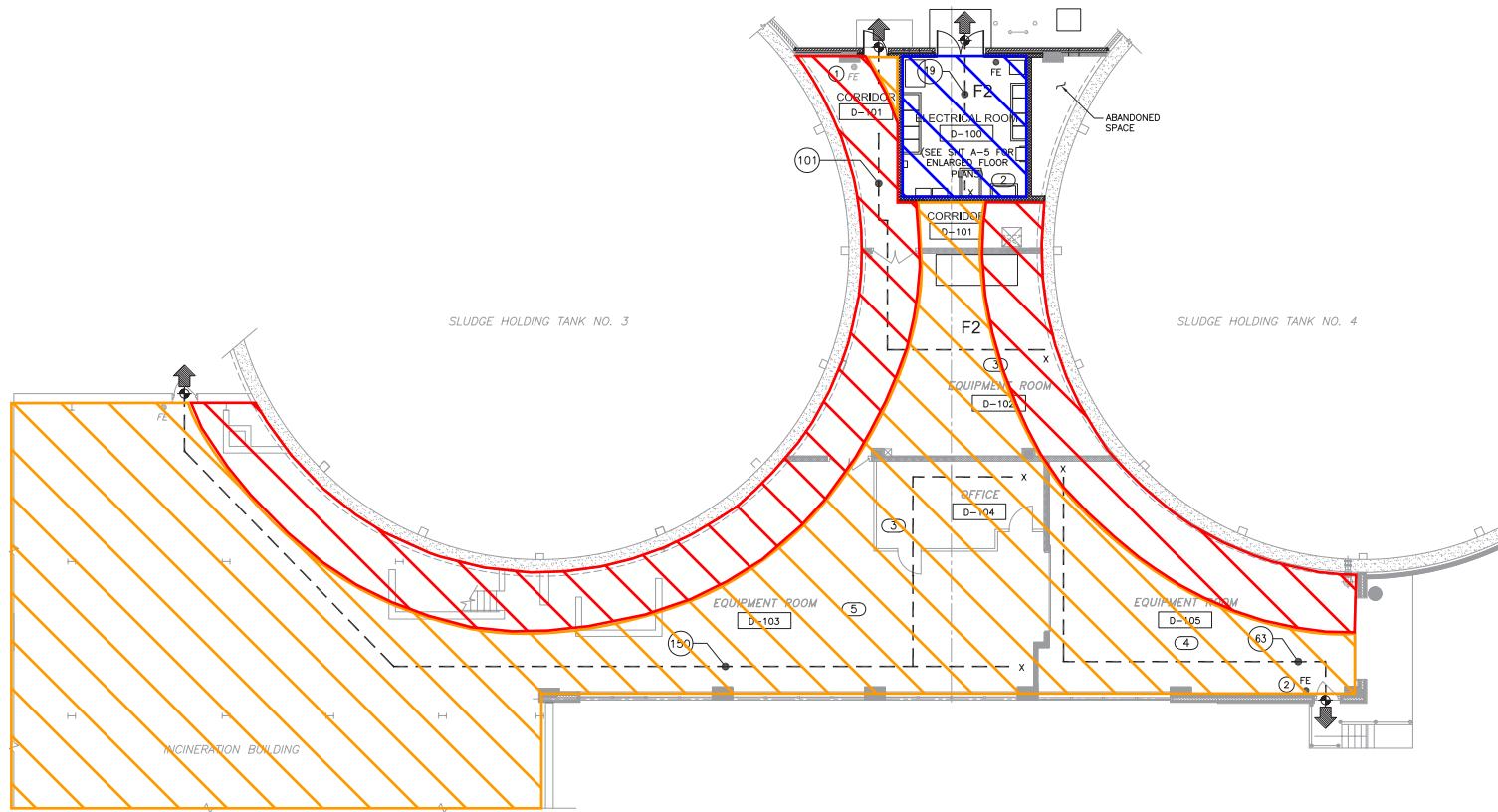


CLASS I DIVISION 1

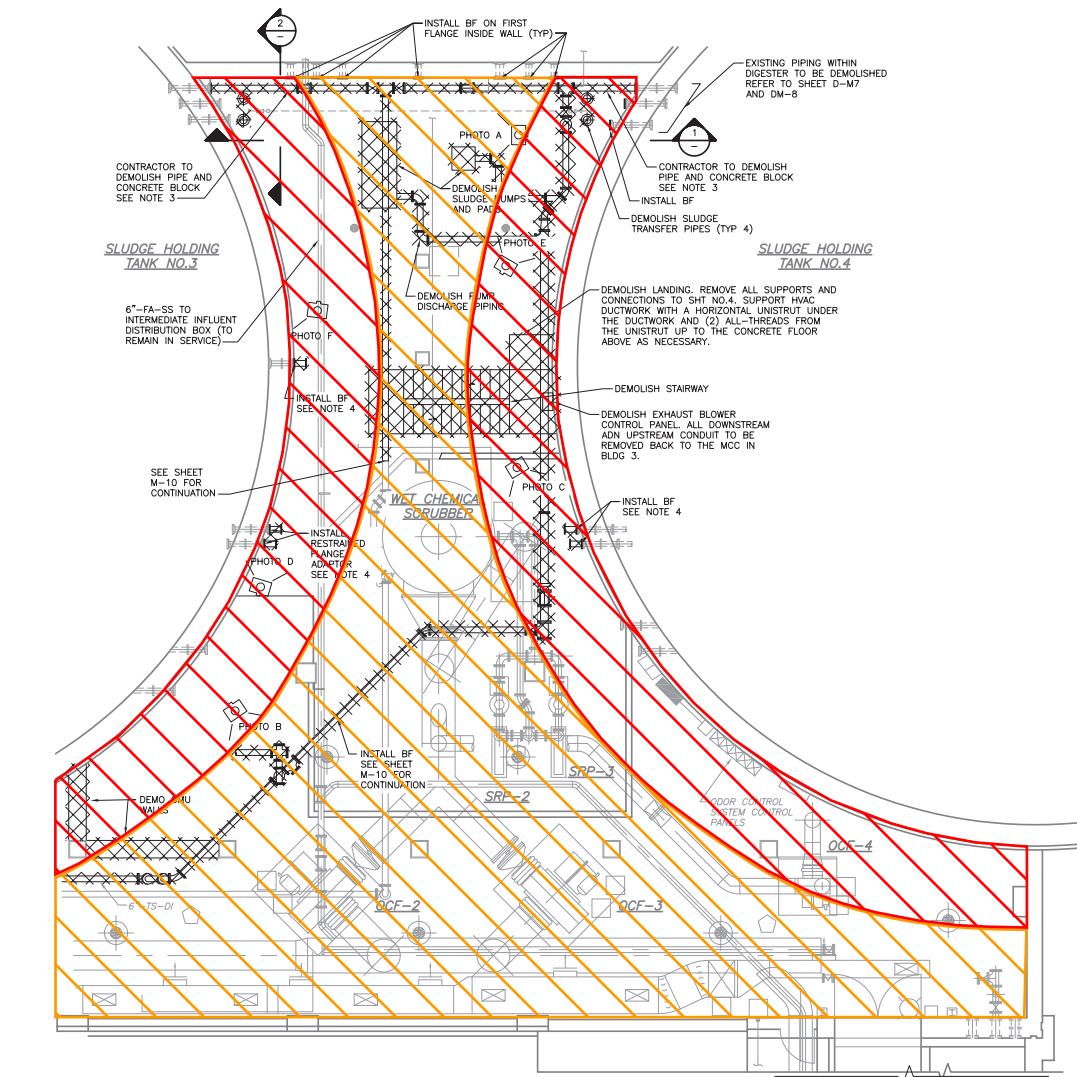


UNCLASSIFIED

JCW NELSON COMPLEX MISSION MAIN BUILDING 3 SPACE CLASSIFICATION SCENARIO 2: VENTILATION AND GAS DETECTION IMPROVEMENTS



BUILDING 3: UPPER LEVEL



BUILDING 3: LOWER LEVEL

NOTES

1. PROVIDE VENTILATION >12 ACH AND LEL/H2S GAS DETECTION EQUIPMENT, RECLASSIFY ENTIRETY OF BUILDING 3 (AND ATMOSPHERICALLY CONNECTED SPACES) IS CLASS I DIVISION 2 (CID2).
 2. AREA WITHIN DIGESTERS AND 5 FT ENVELOPE AROUND THE OUTSIDE WALL WILL STILL BE CID1.
 3. OFFICE ON UPPER LEVEL HAS COMBUSTIBLE CONSTRUCTION, RECOMMEND REMOVAL PER NFPA AND IBC.
 4. ELECTRICAL ROOM IS UNCLASIFIED DUE TO ISOLATION AND VENTILATION.
 5. EQUIPMENT IN LOWER LEVEL INSTALLED VIA CONTRACT 20 IS CID1 RATED.
 6. NEW EQUIPMENT INSTALLED THROUGH THIS CONTRACT WILL BE C1D2 RATED.



CLASS I DIVISION 1



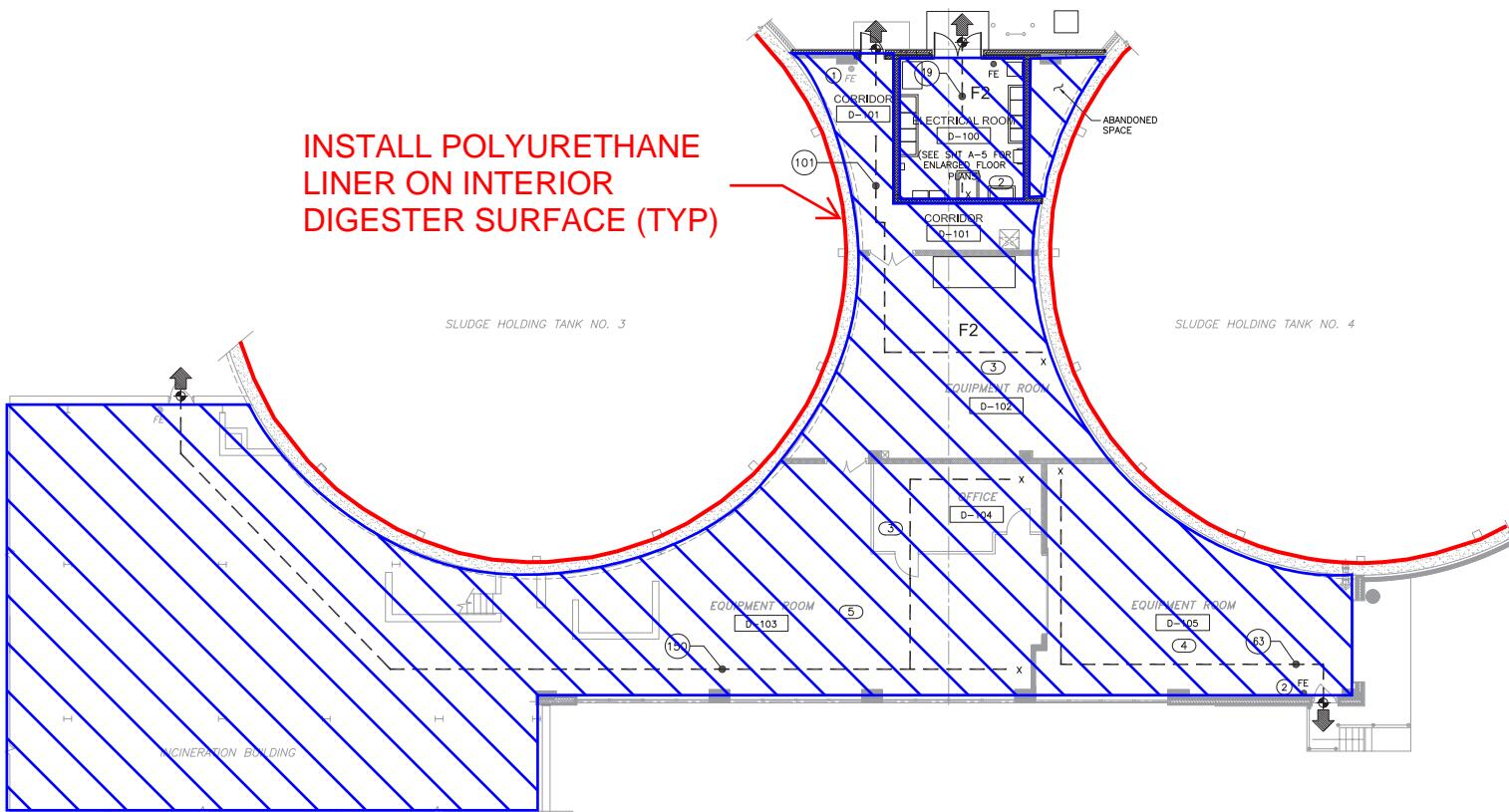
CLASS 1 DIVISION 2



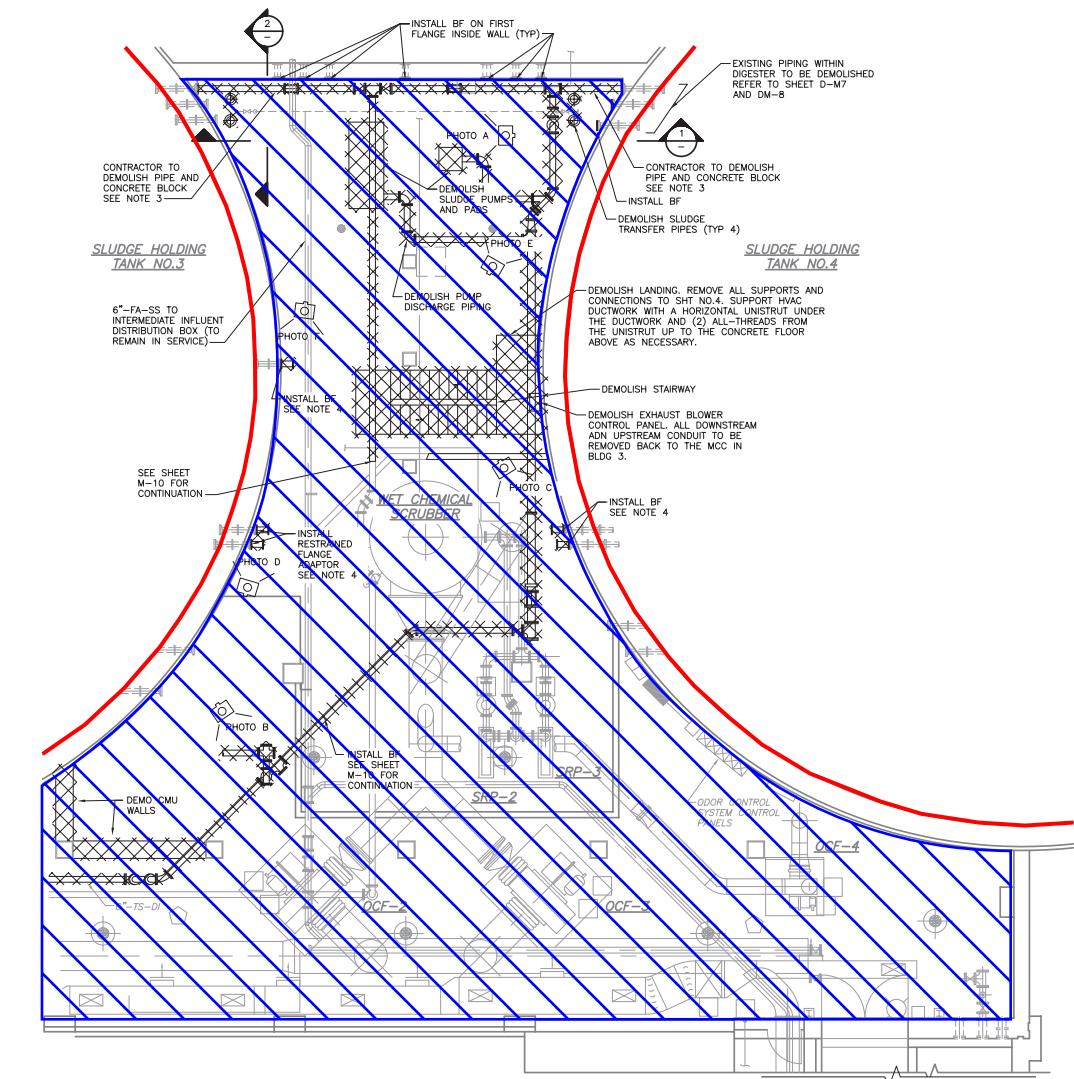
UNCLASSIFIED

JCW NELSON COMPLEX MISSION MAIN BUILDING 3 SPACE CLASSIFICATION SCENARIO 3: POLYURETHANE LINER, VENTILATION, AND GAS DETECTION IMPROVEMENTS

INSTALL POLYURETHANE LINER ON INTERIOR DIGESTER SURFACE (TYP)



BUILDING 3: UPPER LEVEL



BUILDING 3: LOWER LEVEL

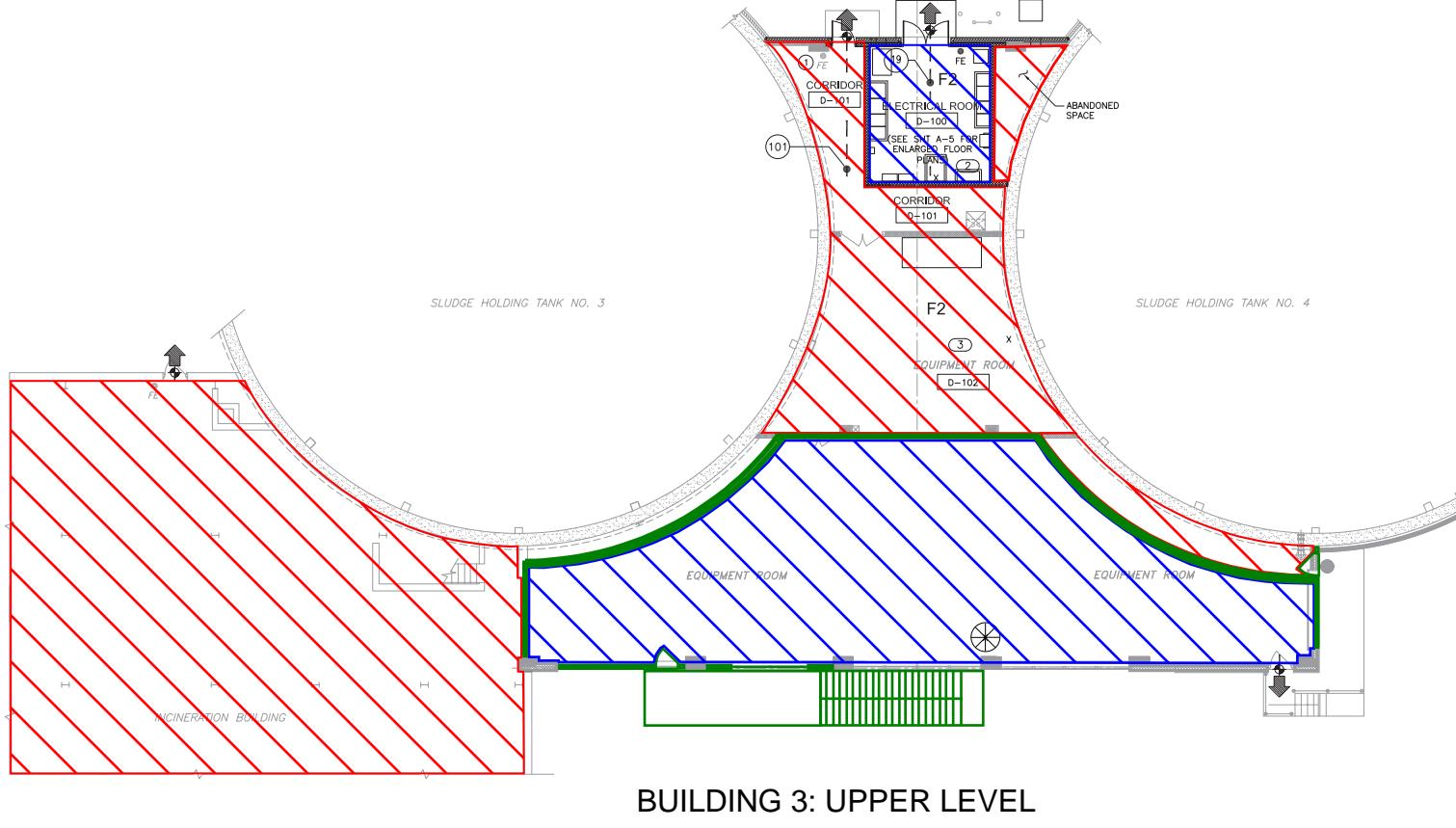
NOTES

1. APPLY POLYURETHANE LINER TO INTERIOR WALLS OF DIGESTER. WITH AHJ APPROVAL, INSTALLATION OF THE LINER WOULD CREATE AN UNCLASSIFIED SPACE FOR THE ENTIRETY OF BUILDING 3 (AND ATMOSPHERICALLY CONNECTED SPACES).
 2. INSTALL VENTILATION >12 ACH AND INSTALL LEL/H2S GAS DETECTION EQUIPMENT.
 3. AREA WITHIN DIGESTERS WILL BE CID1.
 4. OFFICE ON UPPER LEVEL HAS COMBUSTIBLE CONSTRUCTION, RECOMMEND REMOVAL PER NFPA AND IBC.
 5. ELECTRICAL ROOM IS UNCLASIFIED DUE TO ISOLATION AND VENTILATION.
 6. EQUIPMENT IN LOWER LEVEL INSTALLED VIA CONTRACT 20 IS CID1 RATED.
 7. NEW EQUIPMENT TO BE INSTALLED WITH THIS CONTRACT WILL BE UNCLASSIFIED.

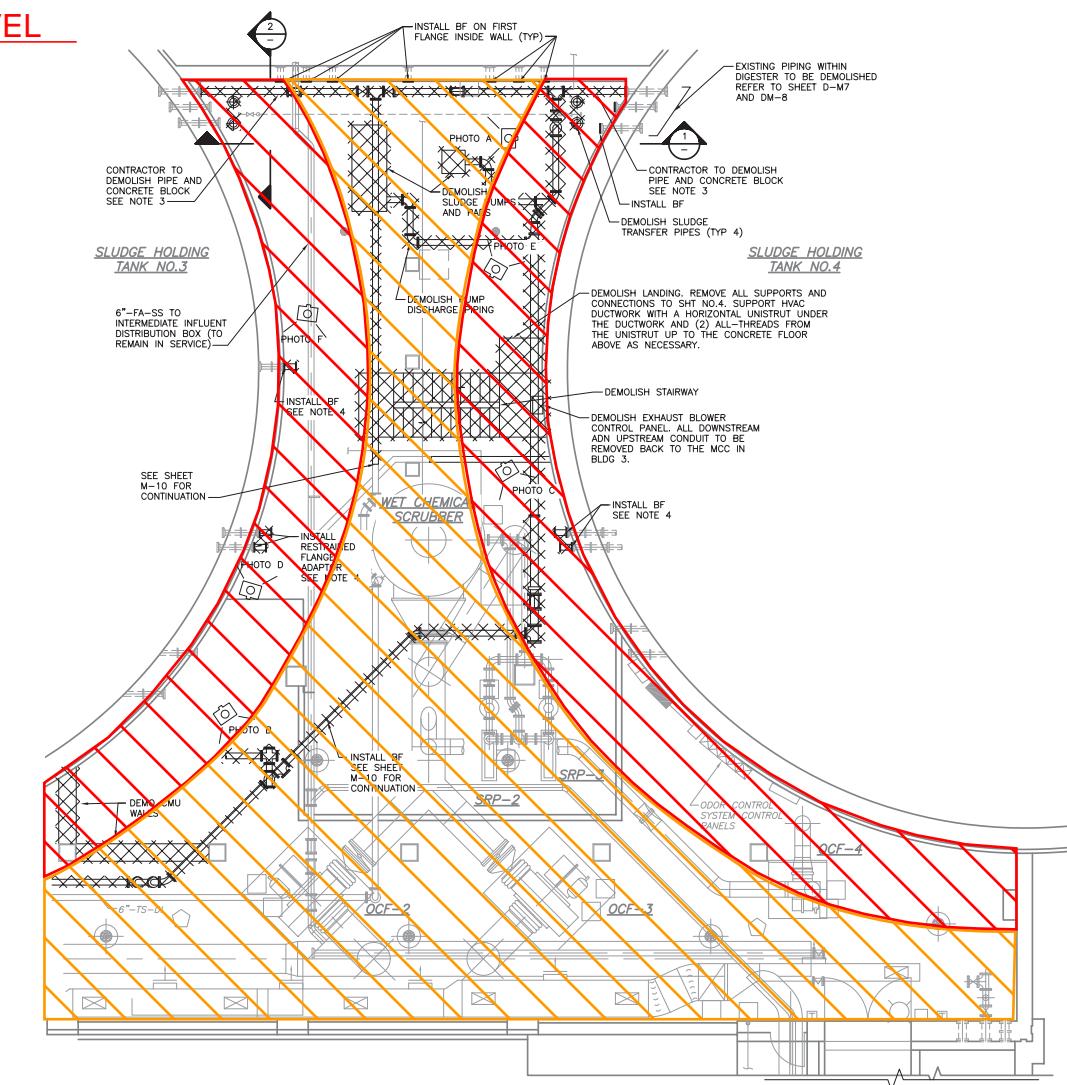


UNCLASSIFIED

JCW NELSON COMPLEX MISSION MAIN BUILDING 3 SPACE CLASSIFICATION SCENARIO 4: INSTALL WALLS ON UPPER LEVEL



BUILDING 3: UPPER LEVEL



BUILDING 3: LOWER LEVEL

NOTES

1. PROVIDE VENTILATION >12 ACH AND LEL/H2S GAS DETECTION EQUIPMENT, RECLASSIFY LOWER LEVEL OF BUILDING 3 (AND ATMOSPHERICALLY CONNECTED SPACES) TO CLASS I DIVISION 2 (CID2).
 2. AREA WITHIN DIGESTERS AND 5 FT ENVELOPE AROUND THE OUTSIDE WALL WILL STILL BE CID1.
 3. ELECTRICAL ROOM IS UNCLASIFIED DUE TO ISOLATION AND VENTILATION.
 4. EQUIPMENT IN LOWER LEVEL INSTALLED VIA CONTRACT 20 IS CID1 RATED.
 5. NEW EQUIPMENT INSTALLED THROUGH THIS CONTRACT WILL BE C1D2 RATED.
 6. OFFICE ON UPPER LEVEL HAS COMBUSTIBLE CONSTRUCTION, RECOMMEND REMOVAL PER NFPA AND IBC.
 7. INSTALL MASONRY WALL OFFSET OF DIGESTER WALL.
 8. SPACE WALL 4 FEET OFF DIGESTER 4 TO PROVIDE ACCESS CORRIDOR TO ELECTRICAL ROOM.
 9. WALL OFF NORTH, WEST, AND SOUTH WALLS OF EQUIPMENT AREA.
 10. INSTALL NEW OVERHEAD DOOR AND TWO ACCESS DOORS.
 11. INSTALL 10 FOOT PLATFORM AND STAIRCASE OUTSIDE BUILDING 3 TO ACCESS UPPER LEVEL.



CLASS I DIVISION 1



CLASS 1 DIVISION 2



UNCLASSIFIED

APPENDIX A3

PROCESS MECHANICAL

This section presents design development of the mechanical systems for the Nelson Complex Biosolids Facilities. The mechanical systems are vital to all processes in the Nelson Complex Biosolids Facilities. The purpose of this TM is to present the general design philosophies and considerations for the mechanical systems.

A3.1 Design Criteria

A3.1.1 Mechanical Systems Outline

Mechanical systems are an important piece of the overall design of the facilities. These systems are part of all the processes in the complex, and also support the processes' functionality.

Below is an outline of the topics covered in this section:

- Mechanical Design Approaches
- Layout and Access
- Hydraulic Calculations
- Pumping Systems:
 - Water and Sludges
 - Motors and Control
- Storage Tanks:
 - Design Codes and Standards
- Material Selection
 - Tank Features
- Piping Systems:
 - Buried
 - Exposed
 - Valves, Gates, and Actuators

A3.1.2 Mechanical Design Approaches

A3.1.2.1 APPLICABLE CODES AND STANDARDS

The mechanical design will make use of many applicable industry standards and design guidance for piping, valves, and process equipment. The following is a list of the more significant resources for design and specification standards. Others will be cited in specific mechanical topics.

- American Water Works Association (AWWA)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)
- Hydraulic Institute (HI)

A3.1.4 Layout and Access

Certain conventions should be followed to make the facility optimally functional, operable, and maintainable. When developing layouts, observe the following guidelines:

EQUIPMENT

- Typically, one type of equipment will be chosen as the basis of design. This make or model is referred to as the “design standard.”
- Required space for equipment removal/replacement/maintenance will be provided in the layout on the drawings.
- Mount equipment and panels on equipment pads to protect them from wash down.
- The minimum clearance on three sides around rotating equipment over 10 horsepower (hp) should be 3.5 feet.
- Leave at least 3.5 feet of clearance between the outermost extremities of adjacent pieces of equipment or between a wall and a piece of equipment.
- Clearance in front of any other equipment face or panel requiring maintenance should be 3.5 feet.
- Pressure vessels should be at least 2 feet from the back wall and 3 feet apart. Sufficient space in front of the vessel should be provided for the face piping plus 3.5 feet.
- For pumps, compressors, and other rotating equipment where parallel units are provided, the orientation of the drive and the rotation should be identical.
- Pumps used for sludge pumping should be arranged to minimize the distance and number of bends through which the liquid must be conveyed to the pump suction.
- For dewatered sludge pumping, utilize ultra-long radius bends (specials) or combinations of 45 degree fittings to minimize frictional losses.
- Provide adequate space for around progressive cavity pumps to facilitate the removal and reinstallation of pump stators.
- Provide adequate headroom for removal of vertical turbine pumps, and/or specify shafts, shaft enclosure tubes (where applicable), and columns in specific length sections that are removable.
- Provide ladders and hatches to access and remove equipment.
- Provide adequate lifting headroom for equipment. An allowance for sling length or lifting beams between equipment lift points and crane or hoist hook also needs to be included.
- Where appropriate provide lifting eyes, in accordance with the standard details, above equipment not otherwise provided with lifting means.
- Place wash down stations in logical areas to facilitate clean-up and pipe flushing. Provide utility stations so that the maximum length of hose required is 50 feet.

PIPING AND VALVES

- Locate piping so that it is not a tripping hazard, a head-banger, or a barrier to equipment access.
- Minimal piping should be located above blowers, compressors, or pumps to facilitate lifting.
- In general, lay out piping close to walls where it can be easily supported, particularly in spaces with high ceilings.

- If piping must be run close to a wall, but not supported from it, leave enough clearance for pipe installation.
- To permit purging of air from the pipeline while it is being filled with water, locate a manual vent valve on the highest point of every pipeline to be filled with liquid or which is to be hydrostatically tested.
- To permit water drainage, locate a manual drain valve on the lowest point of every pipeline.
- Pipe supports and seismic bracing are generally not shown on the layout drawings. Verify, however, that adequate space is available for installation of these supports.
- Provide flexible connections to permit easy assembly and disassembly of piping and connections to equipment.
- When laying out piping, keep the placement of anchors and expansion joints in mind. These must be located on the drawings.
- If piping reducers are required on the suction side of pumps, provide eccentric reducers that are flat on top (FOT).
- Wall penetrations should be perpendicular to the wall.
- Make an effort to keep valves within operator reach (below 8 feet). For any valve over 8 feet above the operating floor, provide a chain operator.
- Do not place swing check valves in vertical piping runs.
- Install an easy disassembly coupling or pipe joint within four diameters of large diameter valves, or valves requiring frequent maintenance.
- Provide thrust restraint for sleeve and other couplings that are not capable of internal thrust restraint.
- Allow ample space for valve and gate actuators.
- Provide adequate clearances for rising stem valves and gates.
- Provide sufficient straight runs for flow meters and other Instrumentation &Control (I&C) elements.

NATURAL GAS, DIGESTER GAS, AND GAS/AIR BLEND PIPING

- Gas pipelines will be sloped downward in the direction of flow and/or be equipped with drip legs at appropriate intervals. Slopes will be 1 percent or more, if possible.
- Drip legs and their drainage will conform to safety codes and permit requirements.
- Branch lines should tee off the main line vertically up or at a 45-degree angle up.
- Piping is to be sized carefully and conservatively to assure the supply pressure requirements of connected equipment are met.
- Gas piping will not be located under building slabs, in crawl spaces, tunnels or galleries, or within unclassified spaces.

A3.1.5 Hydraulic Calculations

CH2M HILL's AFT Fathom hydraulic software package will be used to calculate hydraulics and determine pipe sizing. AFT Fathom performs steady-state, incompressible, Newtonian or Non-Newtonian fluid behavior and energy analysis. Fathom is used to calculate pressure drop and flow distribution in liquid and low velocity gas piping and ducting systems. Sludge flows with solids concentrations of two percent and greater shall be modeled as a Bingham plastic. Where possible, hydraulic calculation shall be designed such that, sludge piping

systems flow velocities are selected to avoid the laminar-turbulent transition (i.e., above the calculated lower critical velocity). In those situations where operation within the laminar-turbulent transition is unavoidable, the Bingham equation for pipe flow velocities up to upper critical velocity shall be used. Fathom can perform calculations with sludges up to 7 percent.

A3.2 Rotating Equipment

A3.2.1 Definitions

Refer to the HI standards for definitions of pump test conditions, specific speed and net positive suction head (NPSH).

The following definitions will apply to the pump applications described in this section:

- “Clear” liquids are those containing only minute quantities and particles of suspended solids (0.25 millimeter or less).
- “Reasonably clear” water will mean water containing either dissolved solids or fine suspended solids (0.5 millimeter or less), or both constituents.
- “Mild slurries” are those carrying finely dispersed, nonabrasive solids.
- “Sludge” is the residue recovered from a settled or filtered waste.
- “Dewatered sludges” are those in which the solids have been concentrated to 12 percent solids content or more.
- “Diluted sludges” are those to which water has been added to facilitate pumping.
- “Heavy sludges” are sludges dewatered to a solids content of 6 to 10 percent.

Using the definitions above, closed impellers will generally be used for clear and reasonably clear fluids and open impellers will typically be used for sludges, slurries, and fluids with stringy material present.

A3.2.2 Pump Types and Applications

CENTRIFUGAL PUMPS

Centrifugal pumps are best used to move large flows at low to moderate heads. Depending upon the impeller configuration, centrifugal pumps can move liquids containing a variety of solid material. Centrifugal pumps, however, do not pump viscous fluids very well. Also, flow from a centrifugal pump is strongly affected by the system pressure, making it a poor selection when a precise flow rate is required. Generally speaking, the use of centrifugal pumps should be explored before considering positive displacement pumps.

The following general descriptions of pumps and applications apply to pumps smaller than 400 hp and would be adequately specified by master specifications. Larger pumps need special specifications with requirements as described under “Centrifugal Pumps 400 hp and Larger”.

HORIZONTAL END SUCTION CENTRIFUGAL PUMPS

Use horizontal end suction centrifugal pumps for pumping or circulating clear or reasonably clear water. Non-metallic fiberglass reinforced plastic (FRP) versions are used to pump chemical solutions and other clear corrosive liquids.

PROGRESSING CAVITY

Use for pumping sludges and for polymer transfer. Progressive cavity pumps are a type of rotary positive displacement pump that has a single-threaded helically shaped rotor turning inside of a double-threaded helically shaped rubber stator. This produces a progressing cavity that moves the liquid through the pump and pressurizes it.

Operating speeds for progressing cavity pumps in sludge applications should be limited to a maximum speed of 200 - 250 rotations per minutes (rpm). Dewatered sludge pumps will require a slower rotational speed.

SCREW INDUCED CENTRIFUGAL

Used for pumping heavy and digested sludges. Screw induced centrifugal can provide higher flow rates than traditional progressing cavity pumps.

METERING

Use solenoid style for the metering chemicals. While not as robust as the hydraulic diaphragm style, solenoids are less expensive and easily replaced.

A3.2.3 Pump Shaft Sealing

SEALS AND PACKING

Generally, pumps will be furnished with mechanical seals. Single seals will suffice for most applications. Consider double seals only for sludges and chemical services, where the shaft cannot be sealed with the pumped fluid and contamination of the pumped fluid with the seal fluid would be unacceptable. Packings will be considered for pump shaft sealing where gritty sludges are expected. External flushing with non-potable, back flow prevention protected (UW) seal water is required for services other than clear water.

MECHANICAL SEALS

Seals will be high quality, split mechanical, cartridge type. Acceptable hard seal face materials include sintered or reaction bonded silicon carbide, or graphitized silicon carbide. Acceptable soft seal face material is carbon-graphite. Both faces will be hard for 5-percent or higher solids by weight in the pumped fluid. Otherwise, a hard-soft face combination will be specified.

SEAL WATER PRESSURE

Seal water pressure will be approximately 3 to 5 psig higher than the seal box pressure. Consult pump manufacturer for seal box pressure. For a rough approximation of seal box pressure, use a minimum of one-half the pump differential pressure plus the pump suction pressure.

Standard details are available for both single and double mechanical seal water supply plumbing to a pump.

BEARING LUBRICATION

Specify grease lubrication for ball and roller bearings, both guide and thrust. Grease-lubricated bearings will be fitted with addition and relief fittings. Consult the pump manufacturers for details of lubrication systems for large equipment.

COUPLINGS

Couplings will be spring-grid or gear type flexible couplings with OSHA coupling guard for pumps which carry their own thrust load. Pump manufacturers also may offer other styles which do not transmit thrust loads, such as reinforced elastomer and diaphragm couplings.

Spacer couplings will be used for pumps which transmit the impeller thrust to the motor bearings, such as in vertical turbine pumps.

Vertical turbine pumps with hollow shaft motors will be furnished with "non-reverse ratchet couplings" to protect the pump and motor against backspin during shutdown and power failure.

SHAFT GUARDS

Shaft guards will be provided on all pumps with any exposed intermediate shafting that presents a safety hazard to operating personnel. The shaft guard will cover the shafting from the top of the pump to a minimum height of 7 feet above the floor or other working surface, or as otherwise required by local safety codes. Two-piece cage guards, split for easy disassembly, will be provided. OSHA approved shaft and coupling guards will be provided for rotating equipment.

A3.2.4 Pump Selection and Hydraulic Calculations

Hydraulic calculations will be prepared for all pump applications. Prepare single-line isometric schematic from pump suction piping origin to point of system discharge for development of the workspace piping description in chosen hydraulic software. This schematic will show line sizes, dimensions, fittings, and piping materials.

Prepare plots of system curve from the system information and impose pump curves on these plots indicating pump operating points for various pump speeds and system head conditions. Indicate on these plots the design operating points and envelope. Conversion of pump operating performance for fluids having viscosities different than water will be determined by the pump manufacturer.

Selected pump operating points will be centered near the pump best efficiency point at the design condition. A rating point selected to the right of best efficiency flow will allow higher efficiency at reduced flow and speed. Caution will be exercised in selecting pump operating

points at the extremes of the pump operating curve due to possible excessive pump shaft radial loading, reduced bearing life, and possible shaft failure.

Care will be exercised in providing adequate overlap of pump performance when multiple parallel pump installations are provided. Proper pump sequencing requires that pumps have sufficient performance overlap to allow transition adding or dropping pumps in operation.

NET POSITIVE SUCTION HEAD

Net positive suction head available (NPSHA) is the system energy available to drive flow into the pump suction at the impeller eye. The equation used to calculate NPSHA is shown below. Specific design characteristics determine the net positive suction head required (NPSHR) by a given manufacturer's pump. NPSHA must exceed the NPSHR of the pump(s) under consideration.

$$\text{NPSHA} = H_b \pm H_s - H_{sf} - H_{vp}$$

where:

H_b	=	barometric absolute pressure at the liquid surface, feet
$-H_s$	=	suction lift, feet
$+H_s$	=	suction head, feet
H_{sf}	=	suction piping friction losses, feet (compute in accordance with Hydraulics Application Guidelines)
H_{vp}	=	vapor pressure of liquid being pumped, feet

Vapor pressure is usually insignificant except when pumping warm or hot water. Keep suction lines short and straight. Check the NPSHR of several pump manufacturers. Design engineer must provide adequate NPSHA plus a margin of safety, because most pump manufacturer's NPSHR curves are based on the pump operation at 3-percent deterioration in head when operating on clean, clear water at the NPSHR value. This is the basis of pump testing for NPSHR in HI standards.

NPSH calculations for centrifugal and vertical pumps must comply with ANSI and Hydraulic Institute requirements (ANSI/HI 9.6.1, *American National Standard for Centrifugal and Vertical Pumps for NPSH Margin*). The standard provides calculation methods and safety factors. The minimum safety factor for positive displacement pumps is 30 percent (i.e., NPSHA/NPSHR = 1.3).

A3.2.5 Materials

Pump materials for typical water treatment applications will generally be iron construction with bronze fittings. There may be certain installations that require selection of corrosion /chemical resistant materials or abrasion resistant materials. Designers will refer to and review the *Corrosion Protection* in making material selections.

A3.4 Storage Tanks

This section will discuss design aspects of metal and FRP tanks and pressure vessels, including codes and standards, material selection, tank features, and other requirements.

A3.4.1 Design Codes and Standards

Tanks and pressure vessels are provided by a variety of standards but are almost always custom built and installed. Tank standards have evolved from industry groups and code agencies, and contain a great deal of experience and methodology that applies to the commercial tank market.

Standards for tanks can be found in many sources. The most common include:

- American Water Works Association (AWWA) – standards for steel tanks for water storage
- American Society of Mechanical Engineers (ASME) – boiler and pressure vessel (B&PV) codes for metal tanks (Section VIII)
- American Petroleum Institute (API) – field-erected, shop-erected tank standards for a variety of tank types
- National Fire Protection Association (NFPA) – standards for flammable liquids and gases, as required by fire and safety codes
- National Institute of Standards and Technology (NIST) – Voluntary Product Standard PS 15 for fiberglass reinforced tanks
- American Society of Mechanical Engineers B&PV code for fiberglass tanks (Section X)

A3.4.2 Material Selection

Typical materials include concrete, stainless steel, steel (rubber lined, plastic lined), aluminum, plastics (PVC, FRP, PVDF, PP), and ductile-iron (cement lined, glass lined) for process areas and mild steel, copper, cast iron, and plastics for nonprocess areas. The storage tank material is determined based upon the characteristics of the liquid or gas that is to be stored. The liquid or gas that is stored should not corrode or deteriorate the storage tank over time.

MANWAYS

Every tank should have a way to enter the vessel for periodic inspection, unless the vessel is quite small (less than 18 inches, typically), when handholes are acceptable for inspection and cleaning.

Manways should meet OSHA standards for size and function. In a practical sense, this means round manways of at least 20 inches in diameter, and oval manways of at least 12- by 16-inch. A common size manway is a circular 24-inch-diameter unit with bolted cover and gasket.

Many manways have davits or hinges provided, especially if the pressure rating of the vessel dictates a heavy flange, or if the flange is located such that it is inconvenient to unbolt and bolt up the cover each time.

Most manways have flat covers, but hemispherical heads are used in high pressure situations.

VENT LINES AND OVERFLOW

Atmospheric tanks should have vent lines provided, often with some kind of insect screen or desiccant breather to protect tank contents. Tanks containing fuels often have flame arresters provided on the vent connection.

The vent line should run outside, or into a suitable ventilation system for exhausting fumes and moisture. Vent lines should be sized to prevent collapsing the tank during pump out or drainage activities.

Just as important for most tanks is the overflow line. The overflow line prevents spilling contents out of the vent line or other nozzles if and when the tank is over-filled. The overflow line is usually routed to a drain or containment system, where the contents can be safely and efficiently handled.

SAFETY AND RELIEF VALVES

ASME defines safety valves as a pressure relief device that opens rapidly by inlet static pressure. A relief valve is defined as a pressure relief device that opens in proportion to the internal pressure. The common application of safety valves is on steam and air service, where a large volume of gas is vented to effect a reduction in pressure. Relief valves are used on liquid systems, where a small amount of liquid will generally effect a reduction in pressure.

ASME requires some form of pressure relief device on a code certified tank properly selected for the service. An alternative to a safety or relief valve is a rupture disc, which also responds to internal pressure, and rapidly releases pressure (without reclosing).

Connection(s) on tanks for these devices should consider the following:

- Relief valves/rupture discs should be as close as possible to the vessel to maintain relief pressure set point.
- Pressure reaction at the valve should be anticipated, especially with discharge piping connections. Often the slip-fit, "umbrella" type discharge connection is appropriate.
- Discharge of rupture discs can be dangerous and should be situated to avoid contact with personnel. Also, some form of protection should be given to the rupture disc element (from the outside) to avoid accidental puncture or damage.

Further detail regarding tank configuration and piping arrangements is included in associated Process and Instrumentation Diagrams (P&IDs).

A3.6 Process Piping System

Process piping includes yard piping, which may be entirely designed and specified outside of the mechanical discipline. Piping for process services and mechanical utilities in the yard also requires civil engineering coordination and consideration for earth loads and traffic loads.

A3.6.1 Design Codes and Standards

State and local codes governing water piping systems, flammable and combustible liquids, flammable gases, and hazardous chemicals are frequently in place. Acquaint yourself with these requirements at the beginning of the project. The design will be based on both the International Fire Code (IFC), as well as the standards of the National Fire Protection Association (NFPA).

Additional design requirements relating to fire protection are discussed in *Section 3.7 Plumbing and Fire Protection*.

NATIONAL STANDARD CODES

National codes applicable to process mechanical piping systems and the addresses at which they can be obtained are presented in **Table A3-1** and **Table A3-2** as follows:

Table A3-1
American National Standards Institute Codes

Code No.	Title
ANSI/ASME B31.3	Process Piping
ANSI Z53.1	Safety Color Code for Marking Physical Hazards

The American Society of Mechanical Engineers
United Engineering Center
345 East 47th Street
New York, NY 10017

Table A3-2
National Fire Protection Association Codes

Code No. and Vol.	Title
NFPA 30, Vol. 3	Flammable and Combustible Liquids Code
NFPA 54, Vol. 4	National Fuel Gas Code

National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

CODE RESTRICTIONS

Piping is furnished in varying chemical compositions and manufactured by a variety of processes. These factors cause pipe within a generic group to have different physical characteristics, such as tensile and yield strengths, creep resistance, resistance to heat, cold, and fatigue, etc. The codes should be checked carefully before choosing piping types and grades for design or specifying them. For example, stainless steel piping manufactured under ASTM A778 and fittings manufactured under ASTM A774 are not recognized in the codes for use in systems which must meet ANSI/ASME B31.3 code requirements. Special service stainless steel must be used for code applications. Check code limitations on piping and components and

the notes and footnotes applicable to the tables of allowable stresses in these codes relative to the standards for piping in the project specifications.

DESIGN STANDARDS

Ductile iron piping systems wall thickness should be designed in accordance with AWWA C150, Thickness Design of Ductile Iron-Pipe. AWWA Manual M41, *Manual of Water Supply Practices – Ductile Iron Pipe and Fittings*, provides design guidance on buried ductile iron piping design for pressure class and thrust restraint.

Fabricated welded steel piping should be designed in accordance with AWWA Manual M11, *Steel Pipe – A Guide for Design and Installation*.

Pipe manufacturers and fabricators also provide much design information, and they should be consulted early in the project.

530.6.3 Pipe Joints for Services and Installations

The following types of pipe joints will be shown on the drawings and specified in order to provide design uniformity:

BLACK STEEL PIPE

- 2-inch and smaller – screwed or socket-welded
- 2-1/2-inch and larger – grooved end, butt-welded, or flanged

GALVANIZED STEEL PIPE

- 2-inch and smaller – screwed
- 2-1/2-inch and larger – grooved end or flanged

COPPER PIPE AND TUBING, GENERAL SERVICE

- Socket joint with 95-5 wire solder

PVC

- Solvent welded, screwed, or flanged

BURIED PIPE JOINTS

- Do not use grooved end joints on any type of buried or submerged piping
- Buried ductile iron pipe – mechanical joint, push-on joint, or proprietary restrained joint ends
- Buried ductile iron pressure piping – thrust blocked, if practical, or proprietary restrained joint ends
- Buried steel piping – coupled with flexible sleeve-type mechanical couplings, bell and spigot joints with retained rubber gaskets, or welded joints. Mechanical couplings and bell and spigot joints in pressure piping will be provided with thrust ties unless thrust-blocked
- Buried joints on ferrous metal piping – bonded for cathodic protection application, as indicated in the *Corrosion Protection* section.

GROOVED END JOINTS (GROOVED END PIPING)

- Grooved end joints (Victaulic or Anvil International, Inc., Gruvlok) are to be shown for exposed piping 4 inches through 12 inches in ductile iron systems. Otherwise, show flanged joints.

- Grooved end joints are to be shown for exposed steel piping 2 inches through 12 inches, except fuel oil, propane, and carbon dioxide will be screwed, butt-welded, or flanged.
- For those services that exclude grooved joints, the specific type of joint to be used will be specified in the piping specification data sheet and shown on the drawings.

A3.6.4 Piping Design Guidelines

PIPELINE VELOCITIES

Gravity Pipelines. These pipelines are:

- Normal velocity: 4 to 5 fps
- Maximum velocity: (to carry gravel): 8 to 9 fps
- Minimum velocity: (to carry sand): 2 fps

Pressure Pipelines. These pipelines are:

- Normal liquid velocity: 5 to 8 fps
- Maximum liquid velocity: 10 to 12 fps
- Minimum liquid velocity: 2 to 3 fps

The maximum and minimum liquid velocities noted above may be exceeded occasionally.

However, this is the design range to be used for normal maximum and minimum flows.

Absolute minimum and maximum liquid line velocities seldom should be less than 1/2 fps or more than 15 fps. Gases in pressure systems may flow at normal velocities, ranging from 1,800 to 8,000 fps with reasonable pressure losses, but this depends on the fluid, pipe size, and system pressure. More detailed guidance is provided in the *Crane Technical Paper No. 410*. The Arrow software also provides an easy method to develop piping sizing and for spotting system elements with the most significant losses.

A3.6.6 Thermal Expansion and Flexibility

Thermal expansion and flexibility design in piping is not usually a major focus of the system design. Unlike pipe support systems, thermal expansion provisions cannot be left to the subcontractor for design when they are required. Once piping is laid out, the potential expansion movement must be calculated with consideration for the pipe length, material, and the range of temperature the piping may experience. Where the expansion is within the allowable flexure and allowable pipe wall stress for the particular pipe material, and where the support system does not hinder movement, then it is best to avoid the use of expansion joints, compensators, or flexible metal hose. Piping systems must be reviewed for thermal expansion needs. Details regarding piping expansion and flexibility are to be developed during final design.

The allowable flexure and expansion stress range for piping systems must be determined in accordance with the requirements of the ANSI codes listed under the Piping Codes subsection. This calculation is independent of that used to determine pipe wall thickness. However, pipe wall thickness must be determined before the stress range caused by temperature expansion of the piping can be calculated. The thermal expansion is then kept within allowable limits by use of selective piping configurations that allow for expansion, or by the use of expansion joints.

In the case of plastic piping, the manufacturers generally provide formulas for calculating the geometry of expansion offsets and loops.

Where expansion provisions are part of the piping system design, the pipe support system must be designed and detailed as necessary to include pipe guides adjacent to expansion joints, pipe anchors to direct the expansion, and intermediate which may be rolling or sliding supports to carry moving piping.

Anchor loads for piping with expansion joints must be calculated to determine if special structural design is required for the structural attachment, or if a special design is required for the anchor attachment to the pipe. The anchor load is caused by the system pressure acting on the expansion joint inside cross-sectional area, plus the joint resistance to compression. Expansion joints should never be applied using more than half of their rated deflections at normal operating temperatures. The contractor should also be directed as to the initial installation condition of expansion joints; whether they are to be compressed, extended, or left at their neutral length, or with length set according to ambient temperature at the time of piping length closure. Where anchor loads would be excessive with expansion joints, flexible metal hose may be considered in a piping offset to eliminate the thrust load due to pressure and joint compression. The flexible metal hose specified has a braided thrust restraining jacket.

As the piping moves to offset the hose ends, the only anchor load is the pipe weight friction component at the hangers and supports.

A3.6.7 Pipe Support

Supports must be provided at changes in direction and adjacent to or under flanges of heavy valve bodies and meter bodies. Future maintenance operations, requiring removal and replacement of piping and valves, need to be considered for selection of appropriate supports and their locations.

A3.6.9 Seismic Design

Sway struts and braces will be provided to restrain piping seismic forces as required by the International Building Code. For low pressure, internally restrained systems will have support system components and spacing/location requirements specified with the detailed layout to be completed in the field and submitted to the engineering team for approval. Other systems that require custom fabricated supports, external restraint or other special circumstance will be designed and detailed on the contract drawings.

A3.6.10 Pipe Accessories and Specialties

Various piping components that are occasionally required for certain systems are sight flow indicators, safety heads, rupture discs, hose and couplings, strainers, and swivel joints. These types of items are to be specified within Specification Section 40 27 01, Process Piping Specialties.

PIPE COATINGS AND LININGS

Corrosion protection by coating and lining is covered by the general and detail piping specifications.

PIPE COATINGS AND LININGS

The common insulations to be considered for application to process piping are fiberglass, calcium silicate, and foamed glass. The specification 40 42 13, Process Piping Insulation, will be followed for this Project. Fiberglass is most frequently used for exposed water handling applications, and although rated to 850°F, it is generally not applied above 450°F. Calcium silicate is generally not applied below 450°F or above 1,000°F. Foamed glass insulation can be rated to 900°F, but would be recommended in water treatment works as an underground insulation, subject to freezing and thawing. Foamed glass (Pittsburgh Corning Foamglas), has low water permeability, low water absorption, low coefficient of thermal expansion, and a high compressive strength. Diesel engine exhaust piping will be insulated with calcium silicate.

Insulation thickness should be selected for economy, and this can be done for a given insulation type by evaluating the present worth of energy loss over a period of time compared to the present worth of the insulation system over the same period of time. Insulation of hot piping for the safe surface temperature to which people may come in contact will be selected to provide not more than 120°F surface temperature.

The various manufacturers should be consulted for recommended vapor barriers, jackets, and finishes. Buried insulated steel and copper piping should be the pre-insulated type with an outer protective conduit. These piping systems are available in many multiple pipe configurations within a single conduit. Typically, the conduit will be PVC pipe which protects both the insulation and internal pipe from corrosion. These systems are proprietary in nature and the manufacturer needs to design for supports and thermal expansion and assist with specifications during design.

A3.7 Valves, Gates, and Actuators

A3.7.1 Isolation Valves and Check Valves

Where flanged ends are specified, valves with rigid grooved ends are also acceptable for general water and air services, provided they meet valve specifications in other respects, and are supported to prevent rotation in the grooves.

Valve types to be used for various services are discussed below. The recommended valve type will be used, unless the specific application requires another type for throttling applications.

A3.7.2 Valve Rating Standards

Valve manufacturers use two basic groups of standards for designating valves flange class. One group of standards covers gate, globe, check, and ball valves for general water, air, steam, oil, and gas services. This group generally uses the ANSI Standards B16.1 (Cast Iron Flanges) and B16.5 (Steel Flanges) for designating body pressure and temperature ratings. The other valve standards group is the AWWA C500 series of standards for gate valves, butterfly valves, and ball valves in municipal utility systems.

The available valve pressure ratings, with minor variations, within the ANSI flange class standards are as follows:

ANSI B16.1

Class 125 - 125 psi SWP/200 psi WOG thru 12"
/150 psi WOG - 14" and larger
Class 250 - 250 psi SWP/500 psi WOG

ANSI B16.5

Class 150 - 150 psi SWP/285 psi WOG
Class 300 - 300 psi SWP/720 psi WOG
SWP = saturated steam working pressure
WOG = nonshock water, oil, and gas working pressure at 150°F.

Screwed end bronze valves through 3-inch are available in all of the above ratings, except Class 250. Flanged cast iron valves, 2-inch and larger are available in Class 125 and Class 250 ratings only. For very high pressure and temperature applications, valves are also available in cast steel and alloys in ANSI B16.5 flange Classes of 600, 900, 1,500 and 2,000.

There is some compatibility of mating cast iron and ductile iron flanges to steel flanges. Class 125 and Class 150 flanges may be mated, although the Class 150 flange has a raised face. Where possible, the joint should be made by removing the raised face from the steel flange, but cast iron-to-steel may be bolted as specified in the piping specification with bolts of specific strength to afford some protection against breaking the cast iron flange.

Class 250 and Class 300 flanges may also be mated. Both of these flanges have a raised face, and the raised face diameter differs slightly.

Under the AWWA standards, valve manufacturers offer valves generally corresponding to the ANSI B16.1 standard for cast iron pipe flanges. Although most manufacturers offer valves in all sizes included in the ANSI standard, the AWWA standards do not include the 14- and 18-inch sizes. Many of the manufacturers of AWWA valves also offer 250 and 300 psi rated versions of

the AWWA gate valves and butterfly valves, although the higher pressure ratings are not included in the AWWA standards for these valves.

A3.8 Odor Control Process Discussion

ODOR COMPOUND ABSORPTION USING pH

The optimal pH set point is essential to ensure efficient transfer of odorous compounds in the foul air such as H₂S from the gas phase to the liquid phase. As shown in Figure A3.8-1, at a pH of 9.3 or higher, more than 99% of the sulfides are present as either HS⁻ or S²⁻ rather than the less soluble un-ionized form. Operation at lower pH will reduce the removal efficiency of the chemical scrubber causing higher sulfide levels in the treated air and can contribute to fouling of the packing due to elemental sulfur precipitation.

The foul air also contains carbon dioxide, which will dissolve in the scrubbing solution at high pH forming carbonates. These carbonates can increase the fouling of equipment. Therefore, increasing the pH above 9.5 has little benefit in removing H₂S and results in increased scaling of the scrubber media and wasted caustic. The pH also directly affects oxidation-reduction potential (ORP) via an inverse relationship. Raising the pH lowers ORP, and operating at higher pH requires more hypochlorite to achieve the same ORP setpoint. Hence operating at pH > 9.5 wastes both hypochlorite and caustic. A high pH setpoint of 9.5 should be used with a low pH alarm setpoint of 9.0.

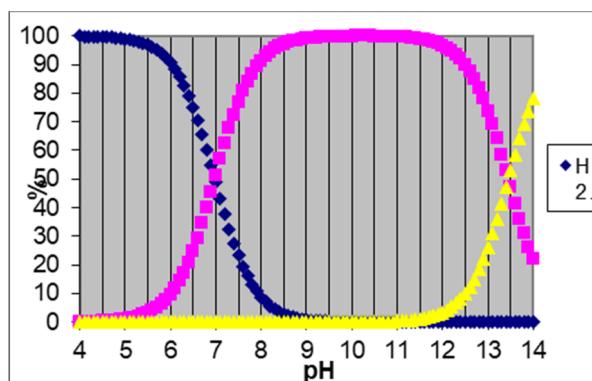
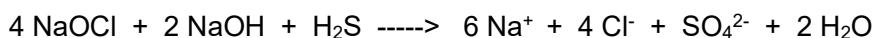


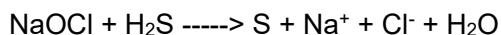
Figure A3.8-1: Speciation of Sulfides versus pH

ODOR COMPOUND OXIDATION USING ORP

ORP is used to control hypochlorite dosing to ensure sulfides are oxidized to soluble sulfate form via the following reaction:



If hypochlorite is underdosed the formation of solid elemental sulfur will occur via the following reaction.



Formation of solid sulfur within the scrubber coats packing, pipes and instruments, reducing the efficiency and reliability of the scrubber. Below a setpoint of approximately 600mV, the ORP response becomes very unstable and is difficult to control. Operation in this unstable zone will result in increased sulfide emissions and formation of sulfur. Overdosing of hypochlorite wastes chemical and increases the odor output of the scrubber associated with the smell of chlorine. ORP probes

have a tendency to drift out of calibration and can only be expected to reliably measure within about $\pm 100\text{mV}$. Therefore, an ORP setpoint of 700 mV should be used with low ORP alarm setpoint of 600mV. Poor ORP control leads to unwanted elemental sulfur formation.

Note that at low pH, the scrubbing solution will predominantly consist of hypochlorous acid (HOCl) instead of the hypochlorite ion (OCl⁻) that predominates at high pH. The increased concentration of the hypochlorite ion (OCl⁻) at high pH reduces the release of chlorine gas, which is odorous.

While the above reactions provide a theoretical basis for understanding the scrubber process, various factors must be taken into account in the design and operation of odor scrubbing systems. These factors are discussed below:

- Control of the scrubbing process is achieved by dosing caustic (NaOH) for pH control and hypochlorite (NaOCl) for ORP control.
- Depending on the NaOCl addition, the ORP value has a maximum value that is dependent on the pH of the solution. That is, holding the pH constant and increasing the concentration of NaOCl will result in eventually reaching a maximum ORP value. Beyond this point, additional NaOCl addition will not result in increased ORP values and hence enhanced hypochlorite ion activity.
- At lower ORP values the ORP value is proportional to pH.
- By increasing hypochlorite activity the ORP value increases and by increasing pH value the ORP value decreases.

BLOWDOWN RATE

The products of the above reactions and dissolved carbonates are removed from the scrubber via the blowdown (bleed off) liquid flow that is sent to waste. This is to prevent an accumulation of sulfates or carbonates in the scrubbing solution. Not bleeding enough can cause fouling or hinder the removal reactions. Over bleeding the scrubber can waste chemicals and water. Ideally, blowdown should be controlled by conductivity measured either in the sump or in the recirculation line upstream of the chemical dosing point. If this method is used, then a setpoint of 15 mS/cm should be used to control the bleed rate. Inadequate blowdown leads to unwanted elemental sulfur formation or increased unwanted carbonate precipitation on the packing clogging up the packing media.

RECIRCULATION RATE AND PACKING

The recirculation rate is set to ensure sufficient scrubbing solution is distributed over the packing to contact the incoming foul air and remove odorous compounds. If the recirculation rate is too low, then breakthrough of H₂S or other odorous compounds may occur. The design recirculation rate should be maintained at all times. A drop off in recirculation rate is usually indicative of a blockage (strainers or spray nozzles). Distribution of the scrubbing solution over the packing is also important to ensure effective mass transfer of sulfides from the gas to the liquid phase. The scrubbing solution should be distributed as evenly as possible over the surface of the packing. Defective liquid distributors, damaged/missing spray nozzles or leaks in distribution headers will cause short-circuiting of scrubbing solution and reduce the surface areas available for mass transfer.

ABSORPTION AND OXIDATION OF OTHER COMPOUNDS

Besides H₂S gas, other odor-causing gases of concerns in the exhaust/ventilation air need to be removed, such as mercaptans, VOCs and volatile fatty acids (VFAs). These compounds are at least as odorous as H₂S and may be present in varying proportions and must, be taken into account in the operation of the odor control system. When present in the foul air, these compounds are

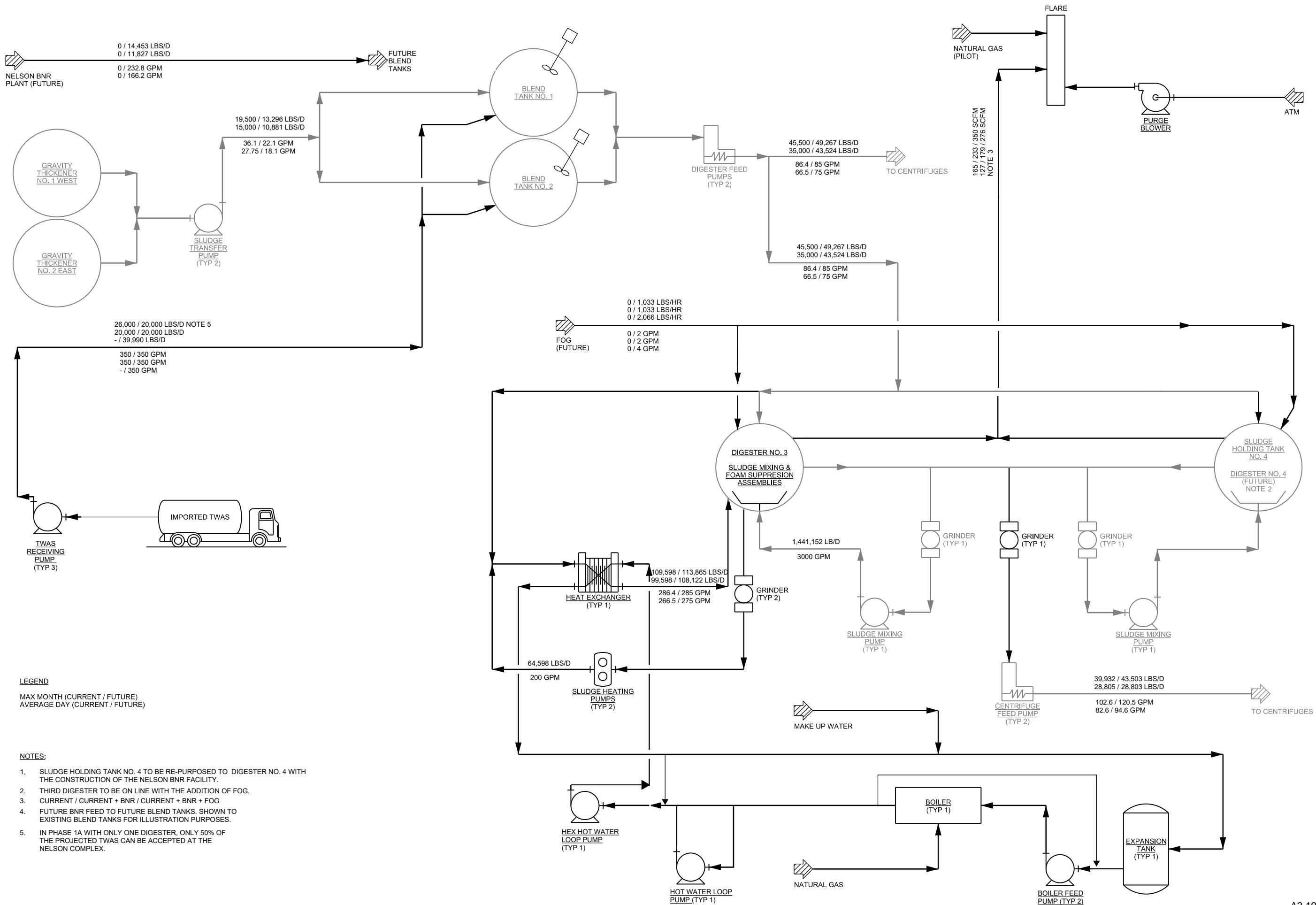
absorbed into solution and/or oxidized thereby placing additional load on the scrubber solution and competing with H₂S for absorption and oxidation, thus creating conditions where an odor outbreak may occur.

SCRUBBER PACKING

The function of the scrubber packing is to continually break up the scrubbing solution as it passes through the scrubber, providing a high degree of surface contact between rising foul air and falling scrubbing solution. This high level of contact improves the mass transfer efficiency of compounds in the foul air to the liquid phase, allowing for oxidation by sodium hypochlorite in the scrubbing solution, forming non-odorous and readily soluble sulfate and reducing odor emissions from the treated air. The current scrubber packing material is a 4" Jaeger Spherical Packing.

SCRUBBER DEMISTER

The function of the mist eliminator is to remove spray droplets contained in the treated air thus preventing mist/droplets escaping to the atmosphere. The existing demister is a Chevron type.



1 2 3 4 5 6

SLUDGE HOLDING TANK NO.4
(FUTURE DIGESTER NO.4)

REFER TO SHEET M-10
FOR IMPROVEMENTS IN
THIS AREA

BUILDING NO.3

SLUDGE HOLDING TANK NO.3
(FUTURE DIGESTER NO.3)

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

AA

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1 2 3 4 5 6

SLUDGE HOLDING TANK NO.4
(FUTURE DIGESTER NO.4)

REFER TO SHEET M-10
FOR IMPROVEMENTS IN
THIS AREA

BUILDING NO.3

6"-TS-DI
(FROM SLUDGE
HOLDING TANK NO.4)

6"-TS-DI
(FROM GRAVITY
THICKENERS)

SLUDGE HOLDING TANK NO.3
(FUTURE DIGESTER NO.3)

ROLL-UP DOOR

INCINERATION
BUILDING

PLAN

3/32" = 1'-0"

ODOR CONTROL PIPING
DISCONTINUED FOR CLARITY

SLUDGE HOLDING
TANK NO.2

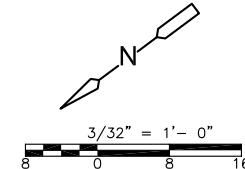
GRAVITY THICKENER
NO.2 (EAST)

SLUDGE HOLDING
TANK NO.1

GRAVITY THICKENER
NO.1 (WEST)

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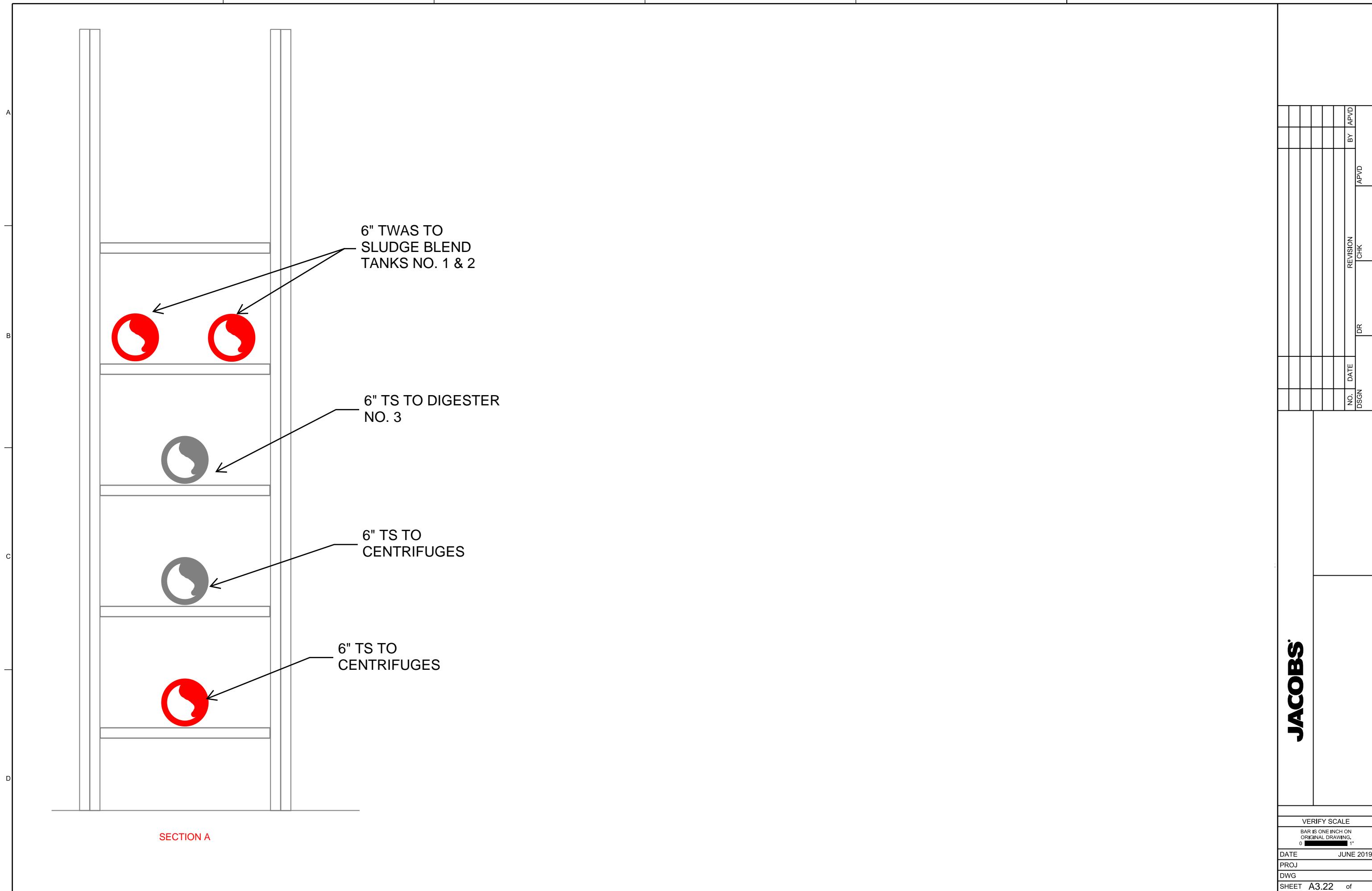
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PLOT TIME:



1, 8" BAFFLE
REQUIRED IN
BOTTOM OF
TANK

4, 8" BAFFLES
REQUIRED IN
TANK,
EQUALLY
SPACES

REPLACE
CENTRIFUGE
FEED PUMP

INSTALL BF
ON BOTTOM OF
VERTICAL TEE

MM-VLV7065
MM-VLV7066

GRAVITY THICKENER
NO.1 (WEST)
(REFER TO SHEET M-2
FOR IMPROVEMENTS)

FROM GRAVITY THICKENER
NO.1 TO SLUDGE
HOLDING TANK NO.1

MM-VLV7040

6"-SC-CI

INSTALL BF

MM-VLV7041

6"-SC-CI

ACCESS HATCH

6"-TS-DI

INSTALL BF

MM-VLV7042

6"-TS-CH

NC

MM-VLV7043

6"-TS-DI

FROM GRAVITY THICKENER
NO.1 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7044

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.2

MM-VLV7045

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7046

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7047

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7048

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7049

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7050

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7051

6"-TS-DI (IN VERTICAL)

MM-VLV7052

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7053

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7054

6"-TS-DI (IN VERTICAL)

MM-VLV7055

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7056

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7057

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7058

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7059

6"-TS-DI (FROM SLUDGE
HOLDING TANK NO.4)

MM-VLV7060

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7061

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7062

6"-PV

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7063

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7064

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7065

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7066

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7067

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7068

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7069

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7070

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7071

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7072

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7073

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7074

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7075

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7076

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7077

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7078

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7079

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7080

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7081

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7082

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7083

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7084

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7085

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7086

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7087

6"-TS-DI

FROM GRAVITY THICKENER
NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7088

6"-TS-DI

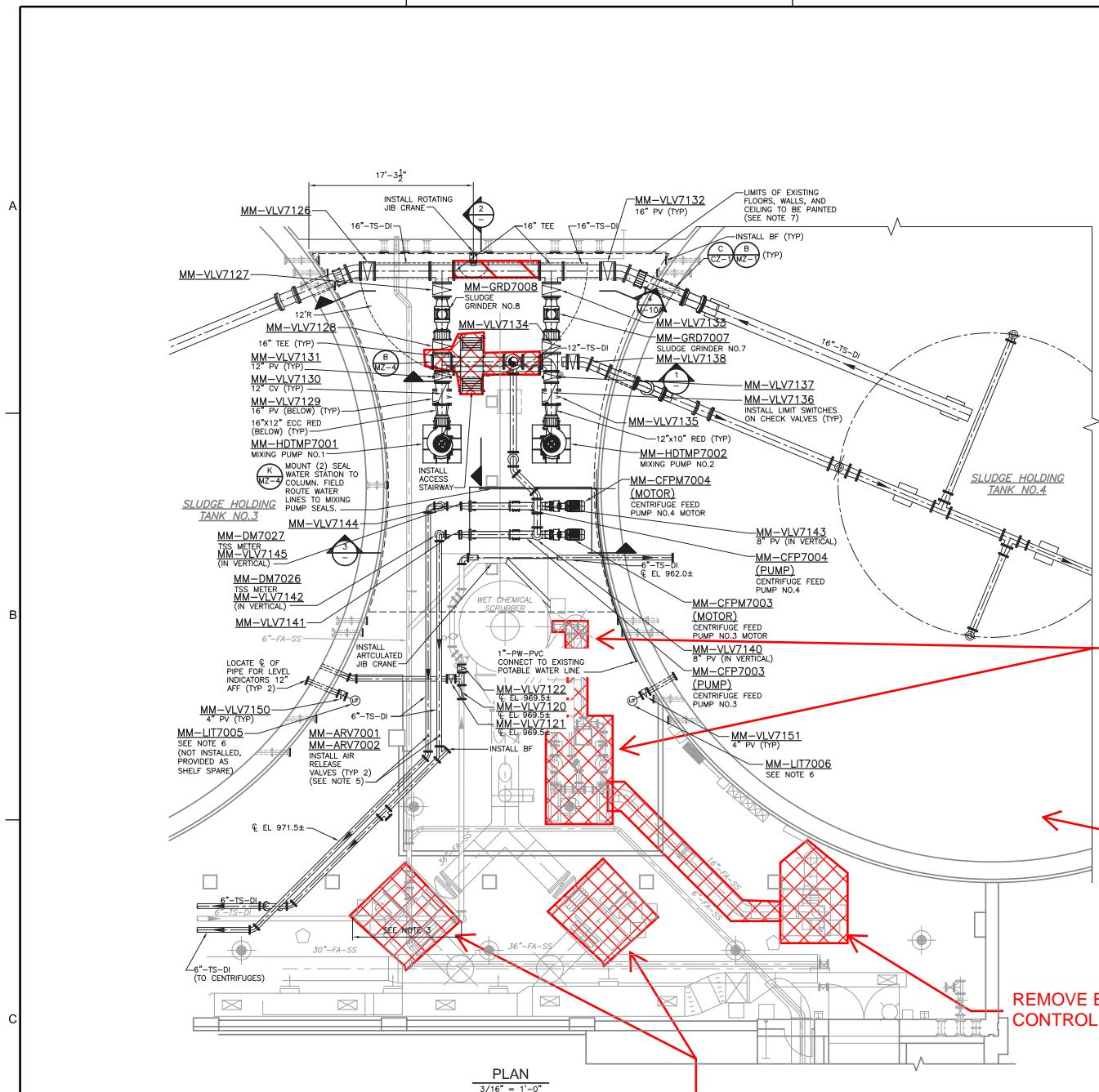
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NO.2 TO SLUDGE
HOLDING TANK NO.4

MM-VLV7089

6"-TS-DI

FROM GRAVITY THICKENER
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HOLDING TANK NO.4

MM-VLV7090

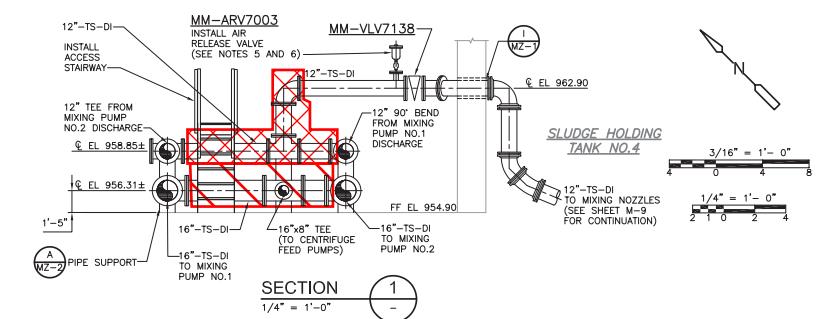


EXISTING RECIRCULATION PUMPS AND PIPING TO SCRUBBER TO BE REPLACED

**SLUDGE HOLDING TANK NO.
4 COVER TO BE REMOVED**

REMOVE EXISTING ODOR CONTROL FAN

REMOVE AND REPLACE EXISTING ODOR CONTROL FAN

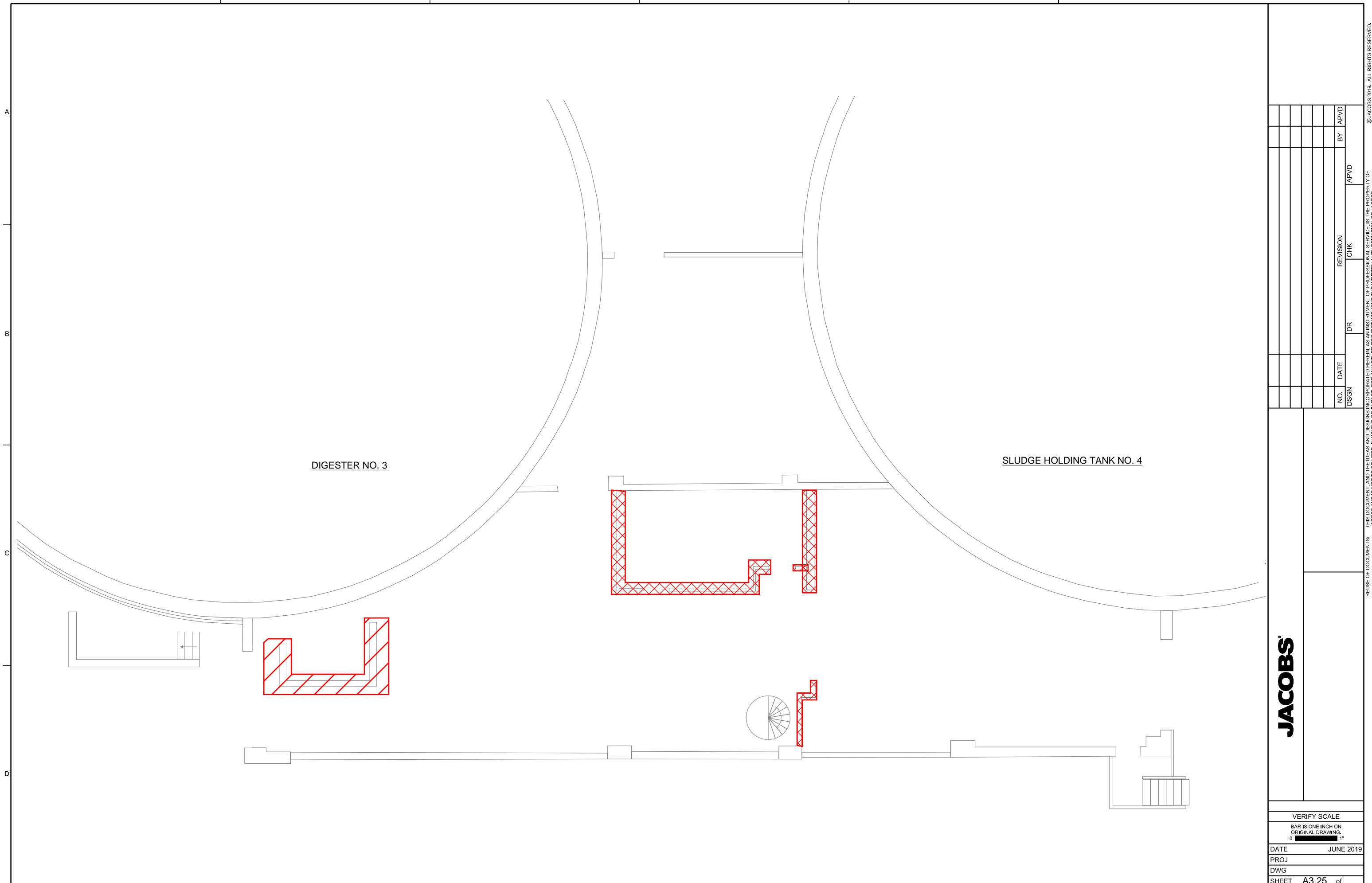


NOTES:
1. BACKGROUND IMAGE FROM CDM SMITH CONTRACT 20 AS BUILT DOCUMENTS. DRAWING M-10.

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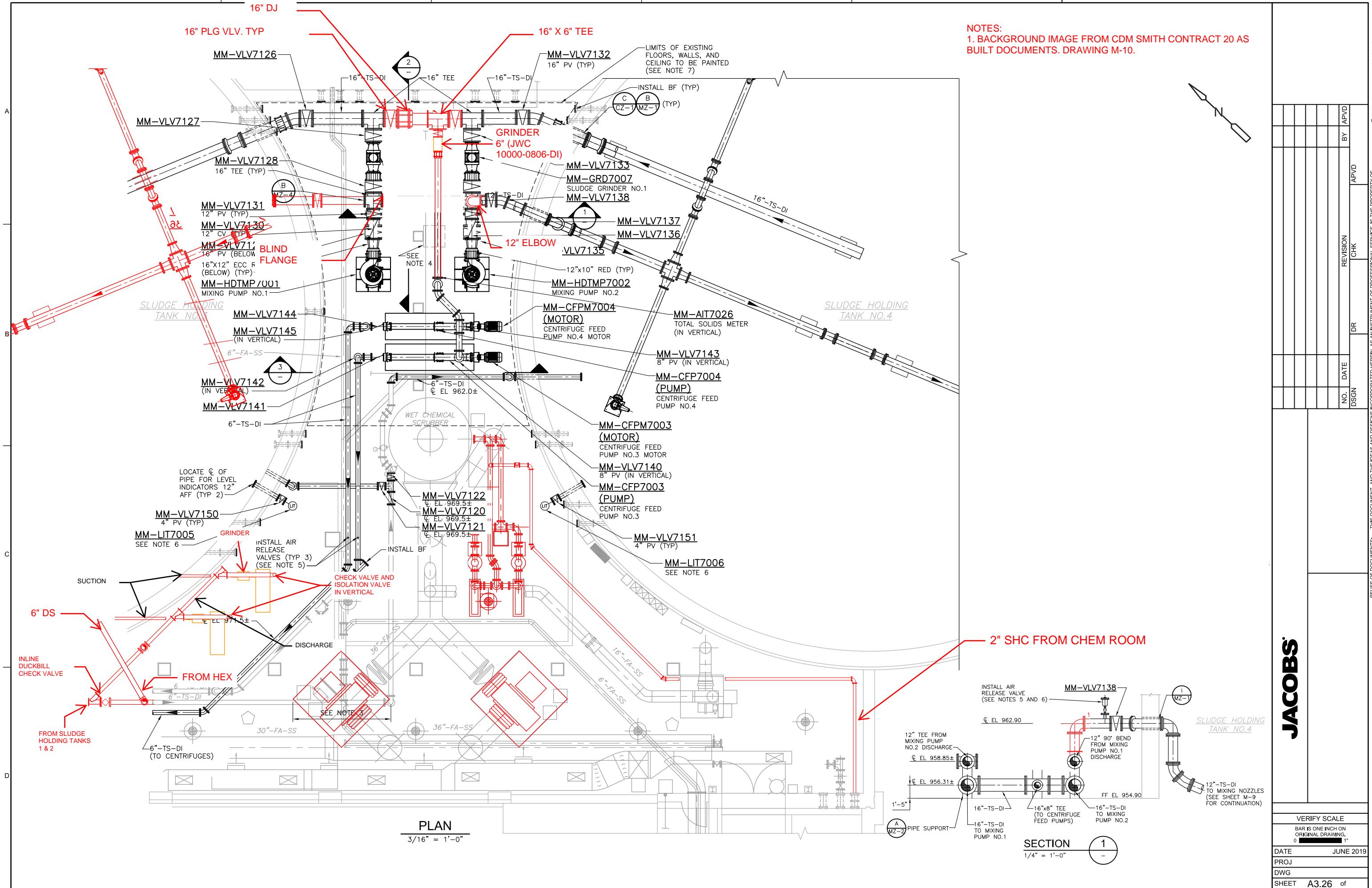
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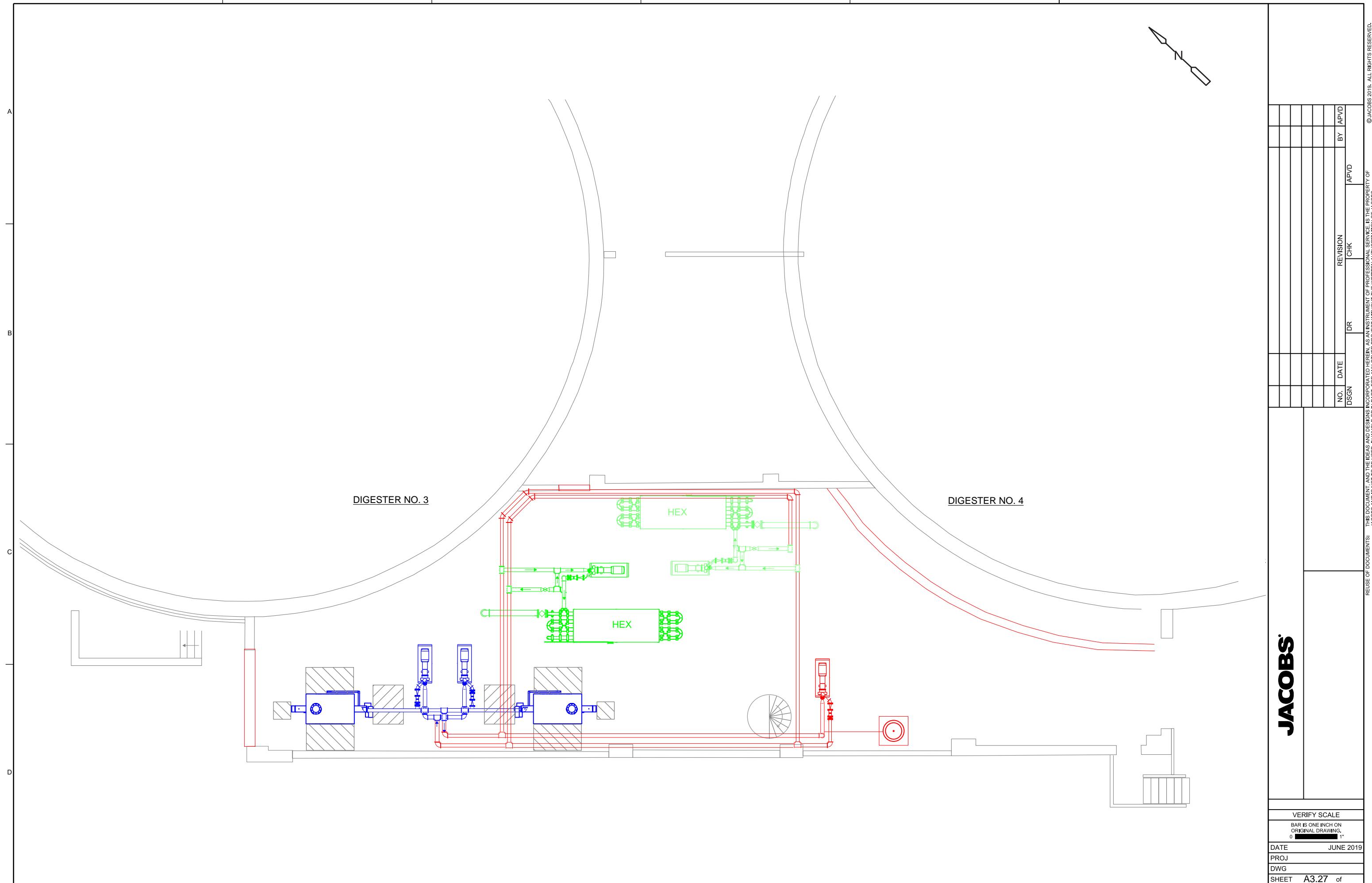
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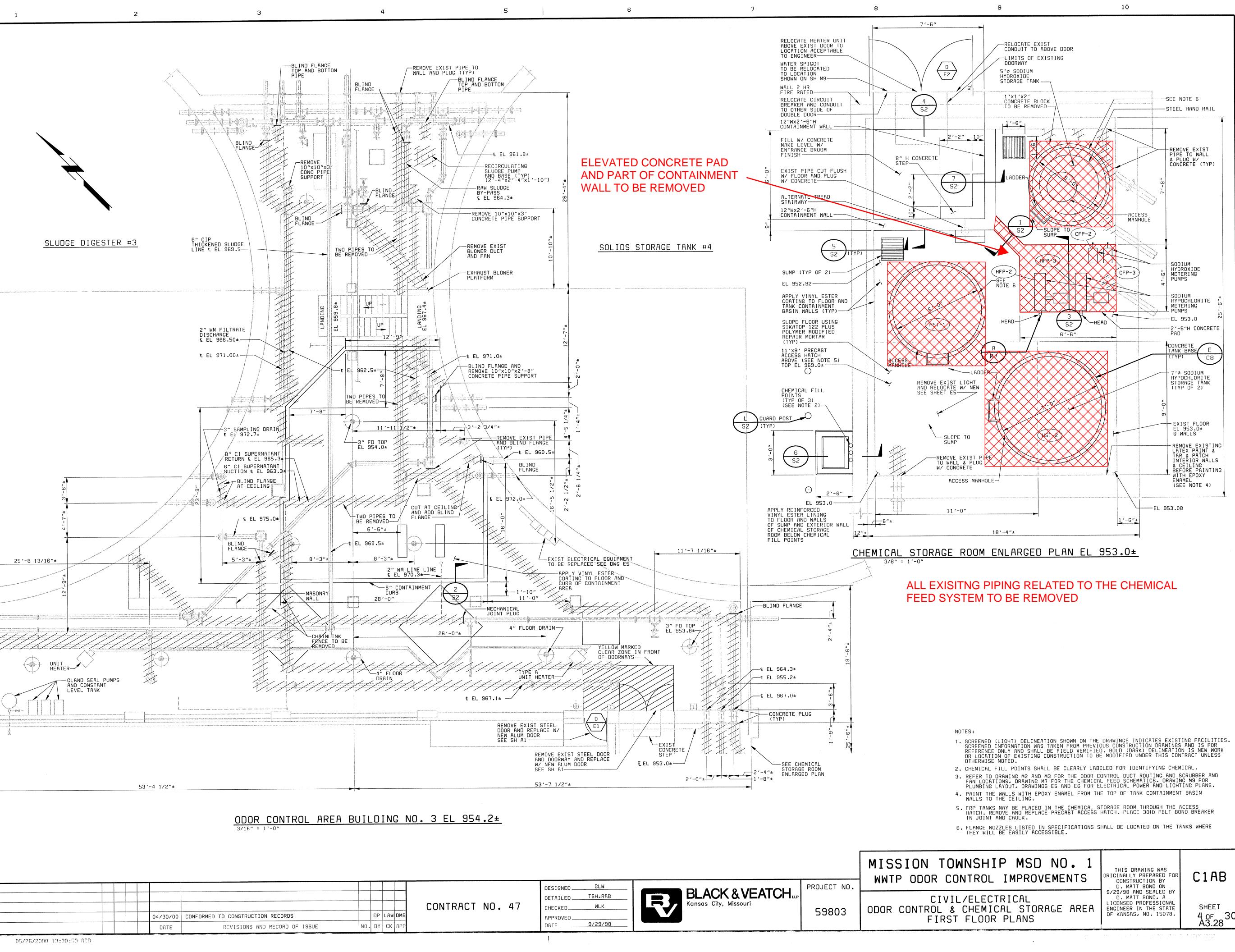
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SHC CONTAINMENT AREA VOLUME: ~681 FT³ - 96.21 FT³ (TANK) + 1.13 FT³ (SUMP) = 586 FT³ = 4,384 GAL

SHC STORAGE TANK VOLUME: ~388 FT³ = 2,900 GAL

FIRE PROTECTION VOLUME REQD (0.25 GPM PER FT³ OF CONTAINMENT AREA @ 20 MINUTES): ~3,400 GAL

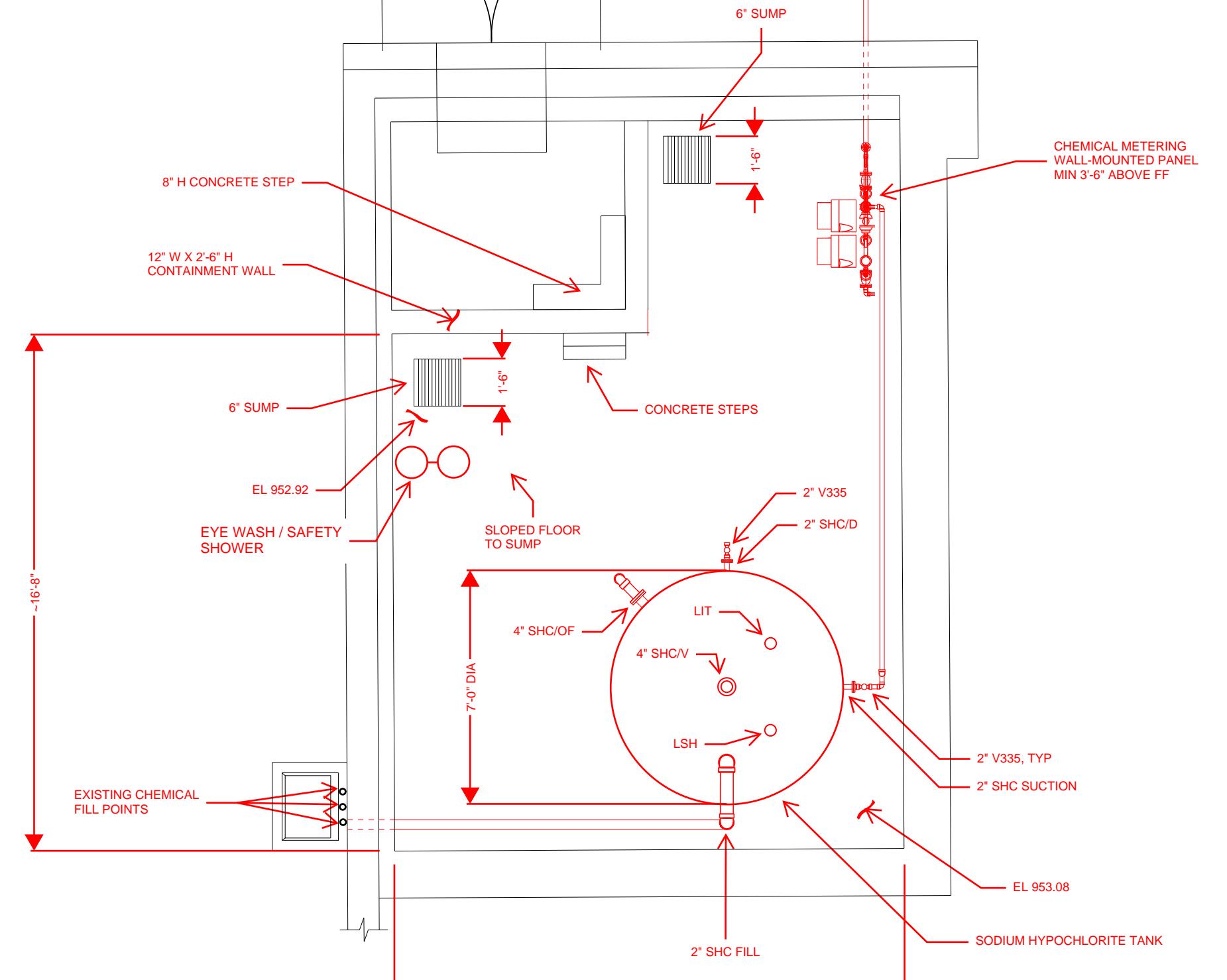
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TO CHEMICAL SCRUBBER



INSTRUMENTATION & CONTROLS

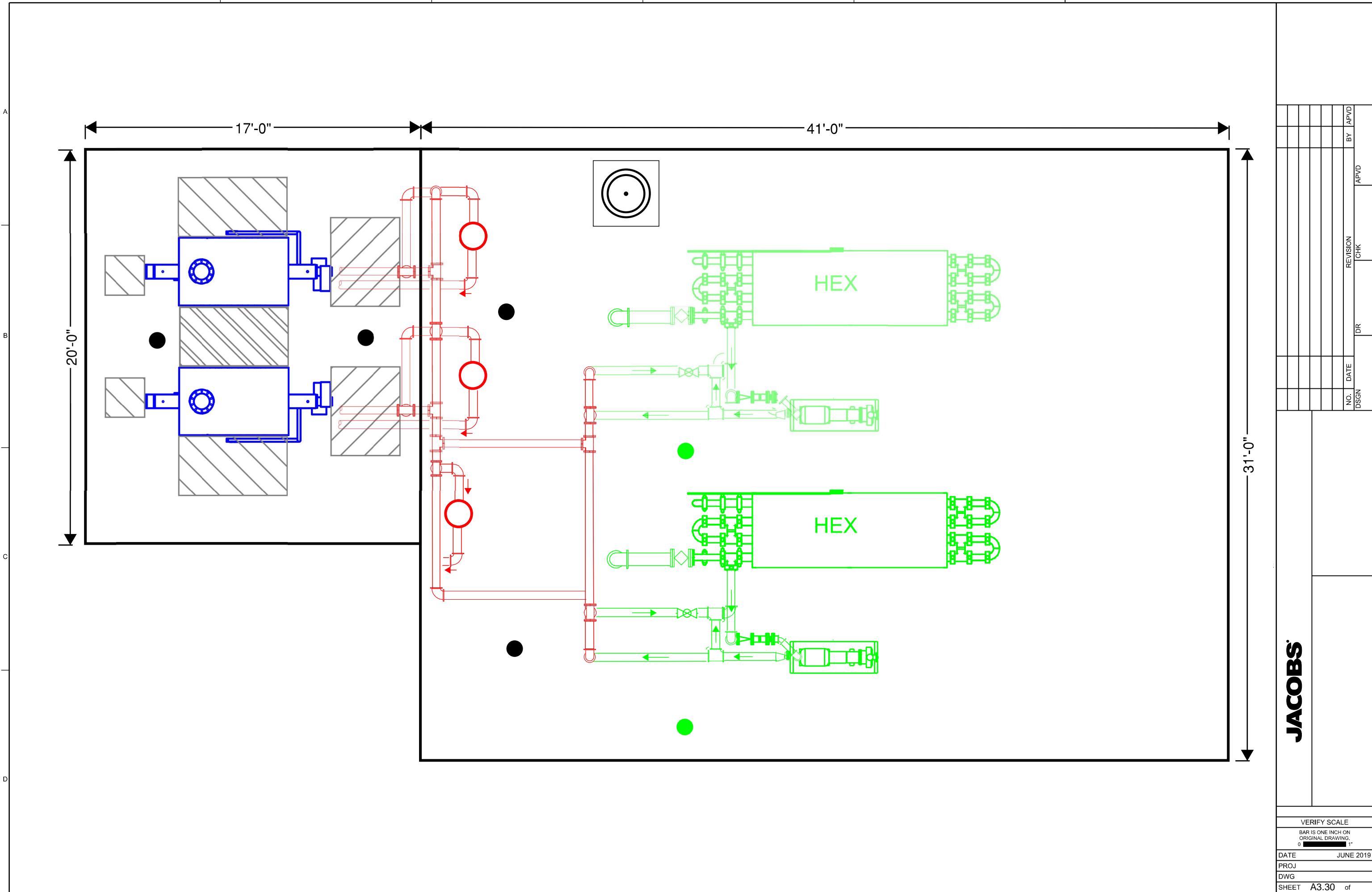
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APPENDIX A4

HVAC AND PLUMBING

A4.1 HVAC Design

Background

The building mechanical system will provide support and infrastructure needs for the renovation being provided as part of Phase 1A Project. The upgrade transforms two existing sludge handling tanks into digesters, resulting in building space classification adjustment to the adjacent Building 3. These spaces are required to meet make-up airflow requirements as specified by the National Fire Protection Association (NFPA) 820. The make-up air will be supplied through corrosive-resistant industrial HVAC equipment.

Design Criteria

In general, Building 3 and possibly the new Digester Control Building are the sole buildings included in the mechanical HVAC portion of this project and will be designed to comply with HVAC requirements per NFPA 820. For buildings not designed primarily for human occupancy or comfort, the building design temperatures are lower in the winter and higher in the summer.

Outdoor Design Conditions

Table A4.1-1 summarizes climate data used for establishing HVAC design criteria. Thermal design parameters for the winter and summer design temperatures listed in the table are in accordance with the 2017 American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook Fundamentals standards based on data for Johnson County Executive Airport, Kansas. The elevation is 1,070 feet for the site.

Table A4.1-1: Climate Data

Criteria	Value
Weather Data Location	Johnson County Executive Airport, KS
Weather Data Location Elevation	1070 feet above mean sea level
Winter Design Temperature	4.3 degrees F (based on ASHRAE Fundamentals 2017, 99.6 percent design criteria)
Summer Design Temperature	96.5 degrees F dry bulb/75.5 degrees F wet bulb F (based on ASHRAE Fundamentals 2017, 0.4% design criteria)
ASHRAE 5 year of Extreme Annual Dry Bulb Temperature	103.2 degrees F maximum -5.6 degrees F minimum

Note:

F = Fahrenheit

Major Design Assumptions

The current design assumptions state Building 3 requires 12 air changes per hour (ACH) to maintain unclassified interior spaces per the code analysis completed by HDR. If a new Digester Control Building is constructed 6 ACH is required to maintain unclassified interior spaces. All new mechanical HVAC equipment will be roof-mounted, and it is assumed the structural integrity of the facility is such that the additional load from the new equipment shall be properly supported. Lastly, it is assumed all mechanical HVAC equipment to remain is adequate in condition, is meeting capacity, and is able to be relocated to meet NFPA 820 requirements.

Indoor Design Conditions

The indoor design conditions are presented in Table A4.1-2.

Table A4.1-2: Indoor Design Conditions

Facility or Building and Space	Temperature	
	Summer, degrees F	Winter, degrees F
Building 3 ¹	103	50
New Digester Control Building	103	50

¹ Existing facility, excluding electrical room

Building Heating and Cooling Design Criteria

Table A4.1-3 presents preliminary building envelope R values and U factors used to determine space heating and cooling loads for Building 3. The building assembly was based on 1956 as-builts; assumptions were made where missing information was determined. If the new Digester Control Building is constructed, the building envelope R and U values will be per the latest International Energy Conversation Code (IECC).

Table A4.1-3: Preliminary Digester Control Building Envelope R and U Values

Assembly	Minimum R Value ^a	Maximum U Factor ^b
Roof – 4" LW concrete	R-5	0.21354
Doors – standard door	R-5	0.2
Windows – single pane, clear, ¼"	R-1	0.95
Walls – face brick, 12" LW concrete, 0.61" insulation	R-16	0.06194
Walls – 8" LW block	R-3	0.29452
Walls – 12" concrete, 2" insulation (int.)	R-8	0.1132

¹ R-Value units are h·square feet (ft²) degree Fahrenheit (°F)/ British thermal unit(s) (Btu).

² U Factor units are Btu/h·ft²·°F.

HVAC General Design Criteria

Table A4.1-4 describes the HVAC design intent for all spaces, including ventilation rate criteria, ventilation system types, heating and cooling system types, basic operating control intent, and general locations where equipment will be mounted.

Humidity in process spaces, galleries, electrical rooms, server rooms, electrical buildings, and control rooms will not be controlled or monitored.

Table A4.1-4: HVAC System Descriptions

Space Description	Occupied Space	Ventilation Rate Basis of Design ^a	Ventilation, Cooling, and Heating Equipment	Heating and Cooling Capacities	Operating Controls	Equipment Mounting Location	Comments
Digester Control Facility or New Digester Control Building	No	6 ACH per Table 6.2.(a) Row 17 Line b 12 ACH is being provided to meet the required flowrate per HDR Code Analysis.	One MAU and one EF. Exhaust fan sizing coordinated with odor control extraction rate.	Gas direct fired air handling equipment will be used for heating. Ventilation air will be used to keep the room below 103 degrees F	MAU and exhaust fan shall run continuously to maintain ACH, air shall be modulated to maintain temperatures	MAU and EF will be roof mounted.	Space unclassified through ventilation. No redundancy typical for process areas.
TWAS Receiving	No	6 ACH per Table 6.2.(a) Row 9 Line b	Existing MAUs and EFs.	NA	NA	NA	The TWAS receiving station will be located within existing building no. 12.

^a All references are taken from NFPA 820-2016 unless otherwise noted.

Notes:

ACH = Air Changes per Hour
EF = Exhaust Fan
SF = Supply Fan
MAU = Make-up Air Unit

General HVAC Equipment Selection Criteria

QUALITY

Systems will be selected that exhibit high reliability and long service life. Process areas will be served by industrial-grade heavy-duty equipment. The industrial HVAC equipment will be corrosive resistant per the clients requested directive. This design directive is to match the existing installation methods currently on site. Refer to the schematic design package for equipment examples.

DUCTWORK MATERIALS OF CONSTRUCTION

Ductwork, in general, will be galvanized for the supply, return, and exhaust air services. The ductwork in the corrosive environments will be aluminum.

AIR FILTRATION

HVAC equipment with air filters will use minimum efficiency reporting value (MERV) 8 filters. Make-up air units with 100 percent outside air requirements under all ambient conditions will be specified to include synthetic media and frame type filters that will not fail when wet. No beverage board filters will be allowed.

WIND LOADING

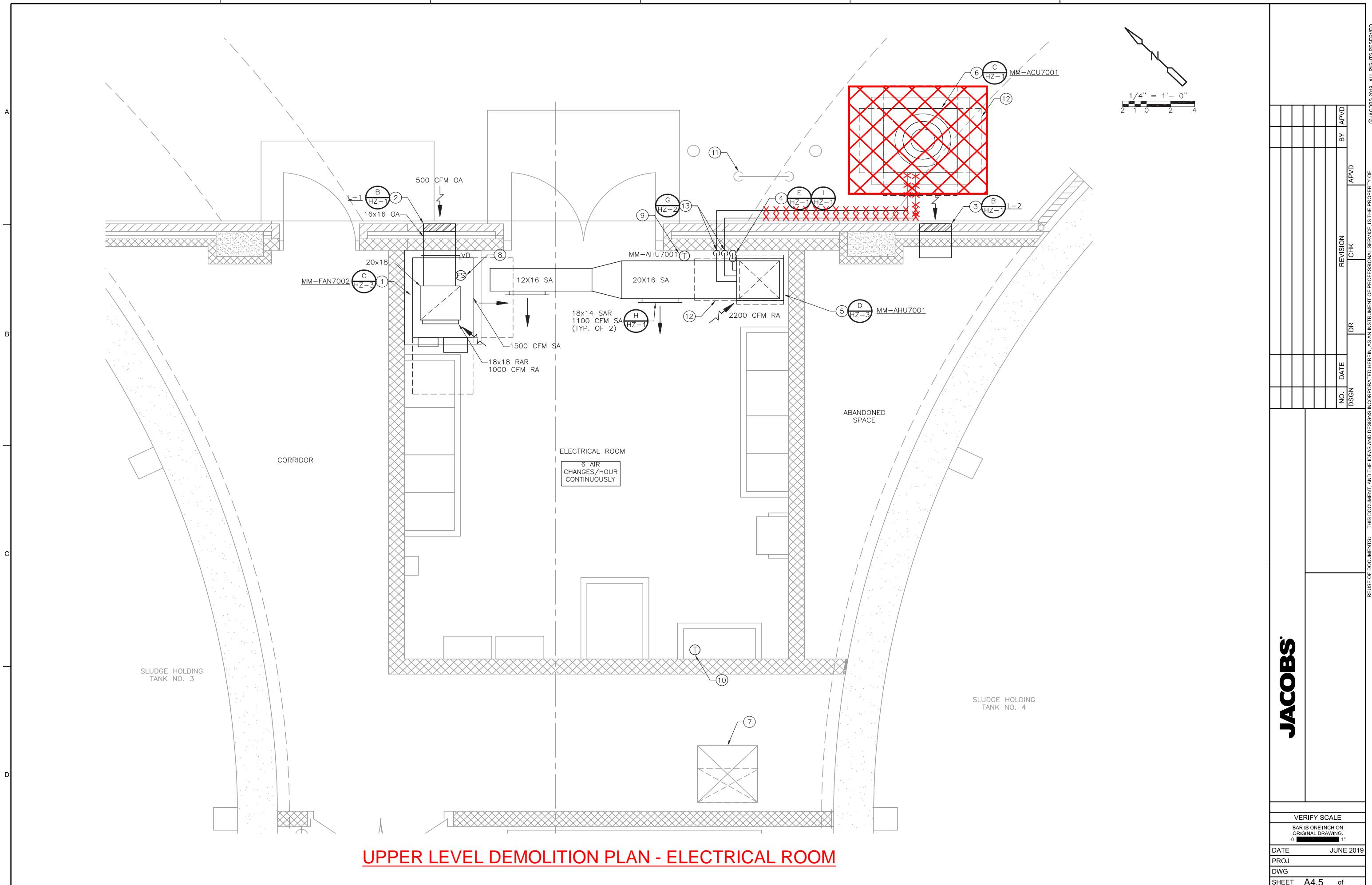
HVAC external components, such as gas vents and ductwork will be designed and installed to withstand specified wind loads. Seismic loading restraint is not a consideration for this site.

HVAC SYSTEM CONTROLS

Control systems used for the HVAC equipment will be electronic controls, incorporating manufacturer-provided controls where possible.

NATURAL GAS

The natural gas supply and distribution system will be developed and coordinated with the local utility company. Natural gas will be supplied from existing site service if possible. If new service is needed, natural gas will be metered at the new site service entrance and routed through the site at a higher pressure appropriate for site-wide distribution. At the use location, natural gas will be isolated with a local shut-off valve and regulated to a pressure (for example, 2-pounds per square inch or less) appropriate for localized use and distribution.



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10 of 10

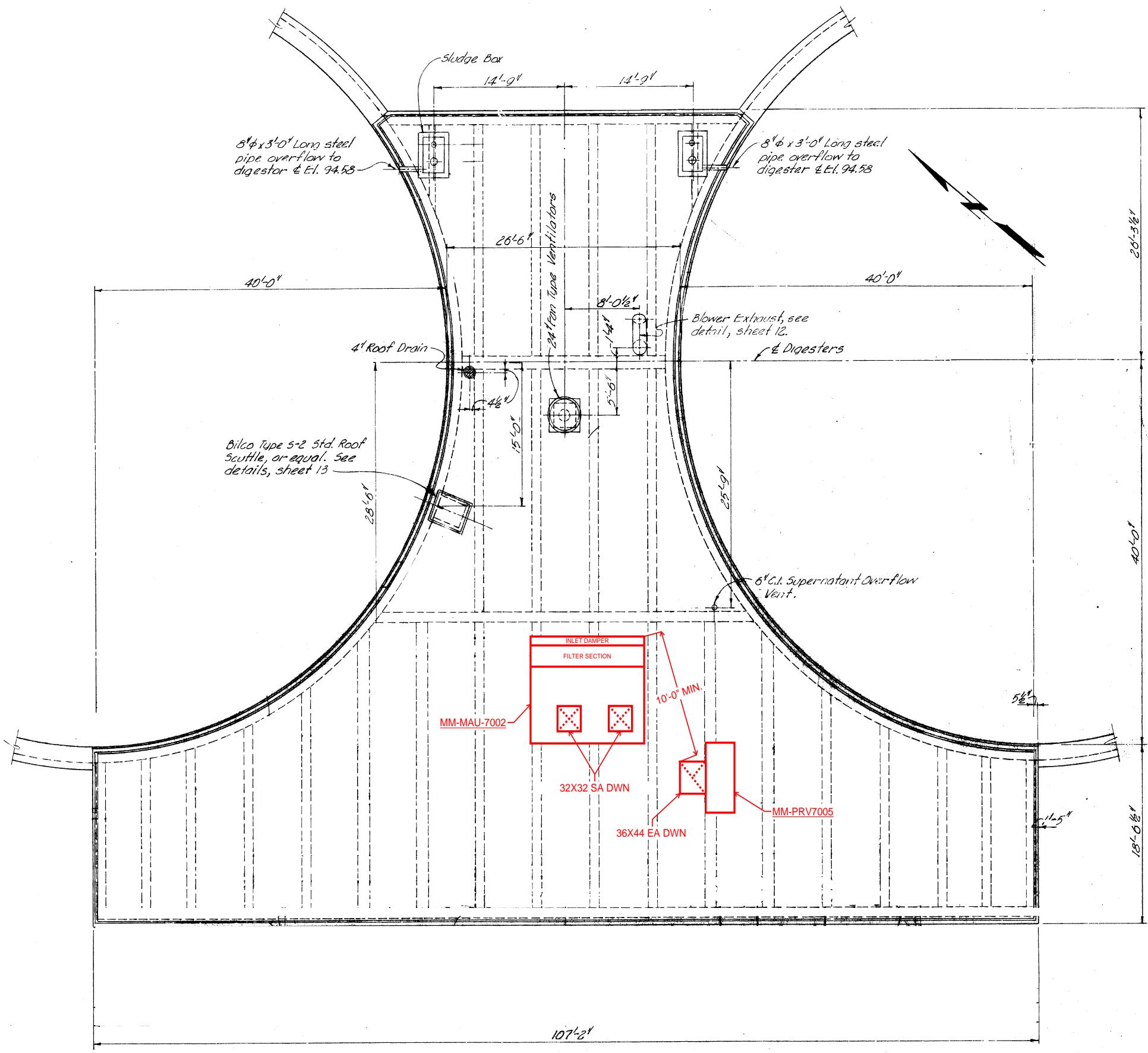
UPPER LEVEL DEMOLITION PLAN - ELECTRICAL ROOM

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GENERAL NOTES:

- ## **1. MOUNT ALL HVAC EQUIPMENT OUTSIDE OF THE CLASS I DIVISION 2 PERIMETER.**

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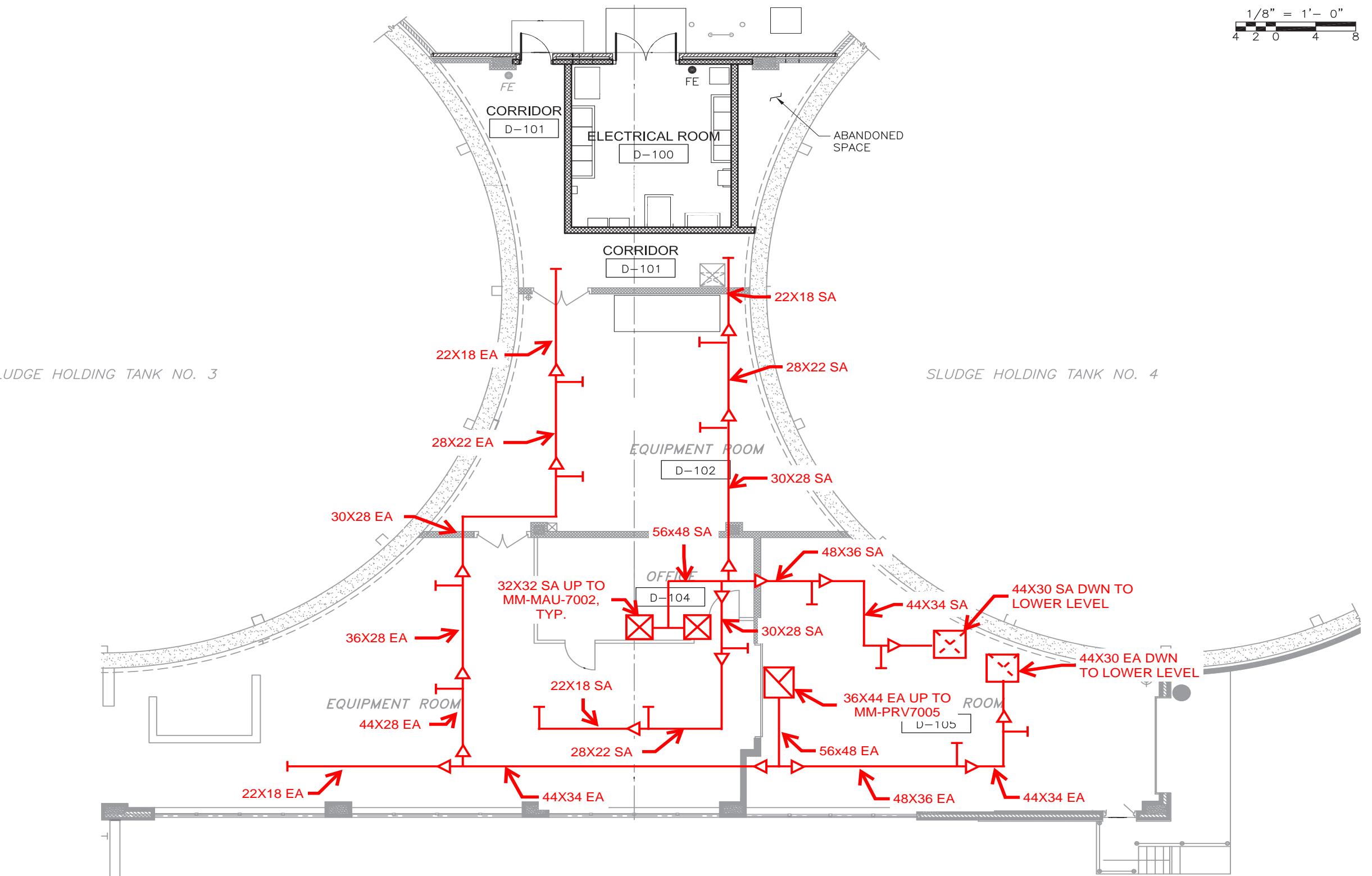
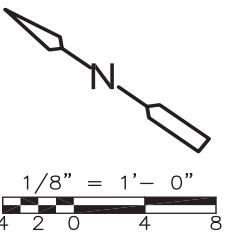
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UPPER LEVEL PLAN

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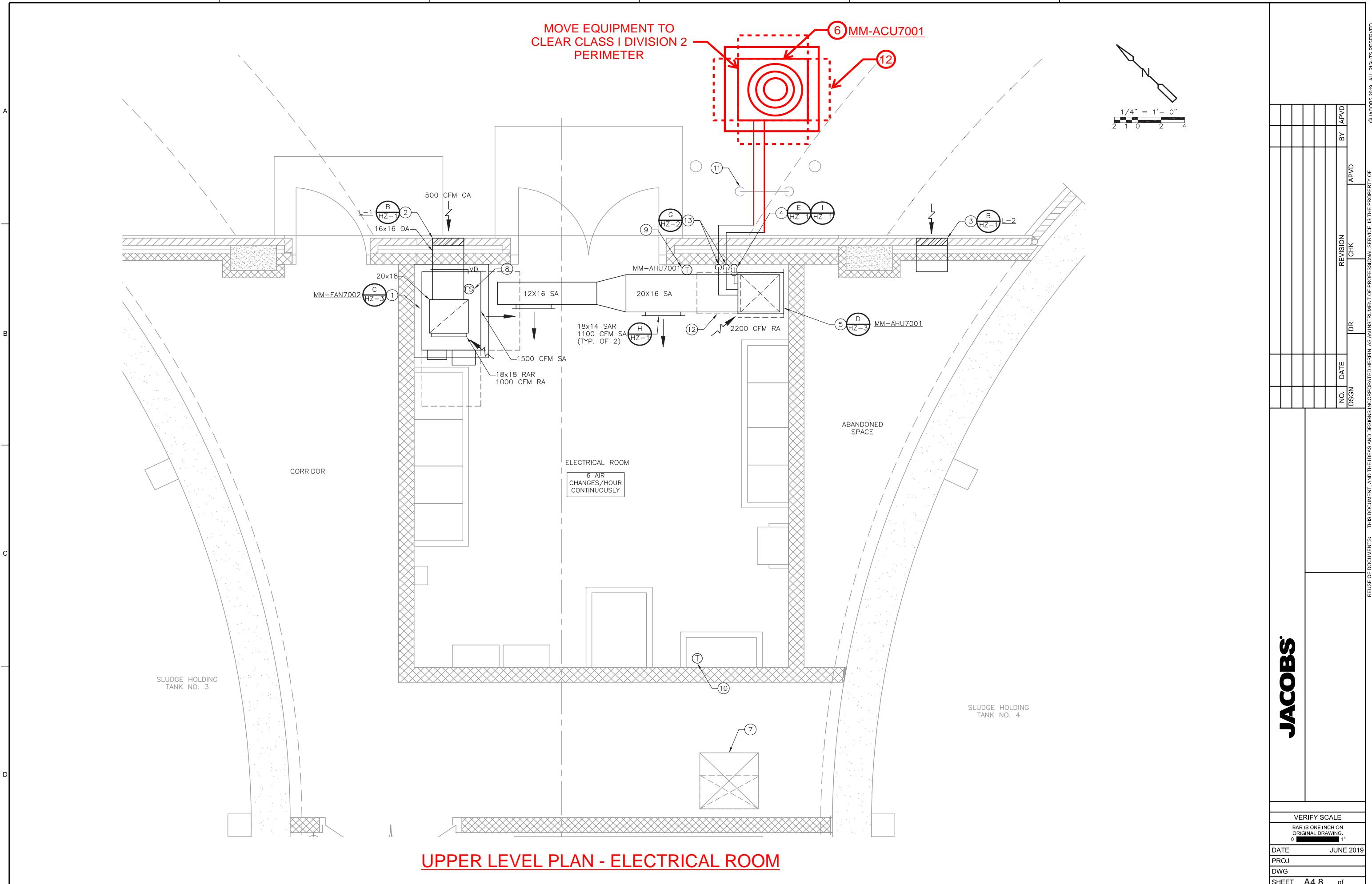
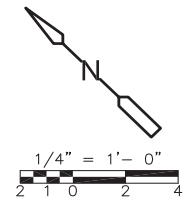
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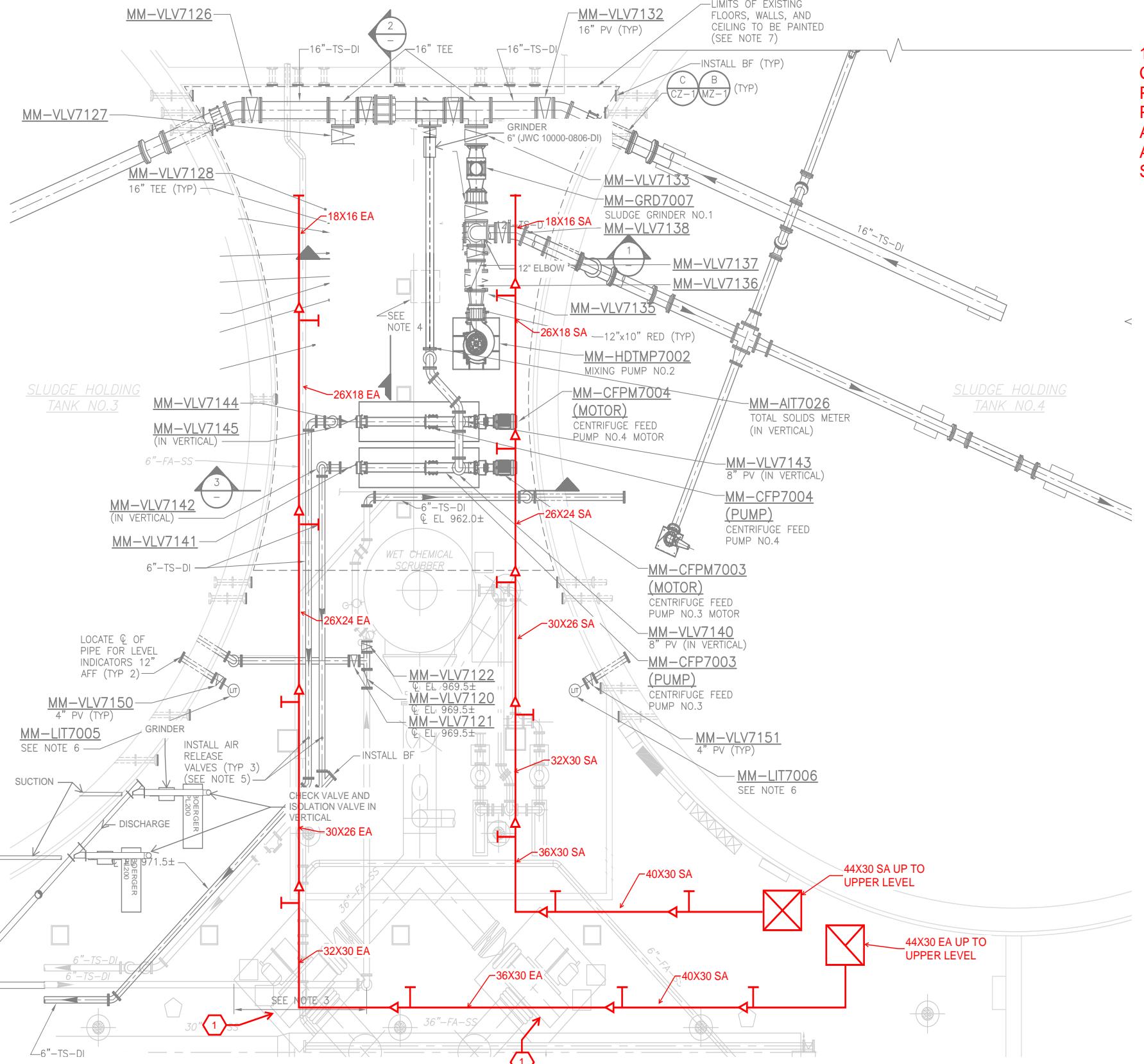
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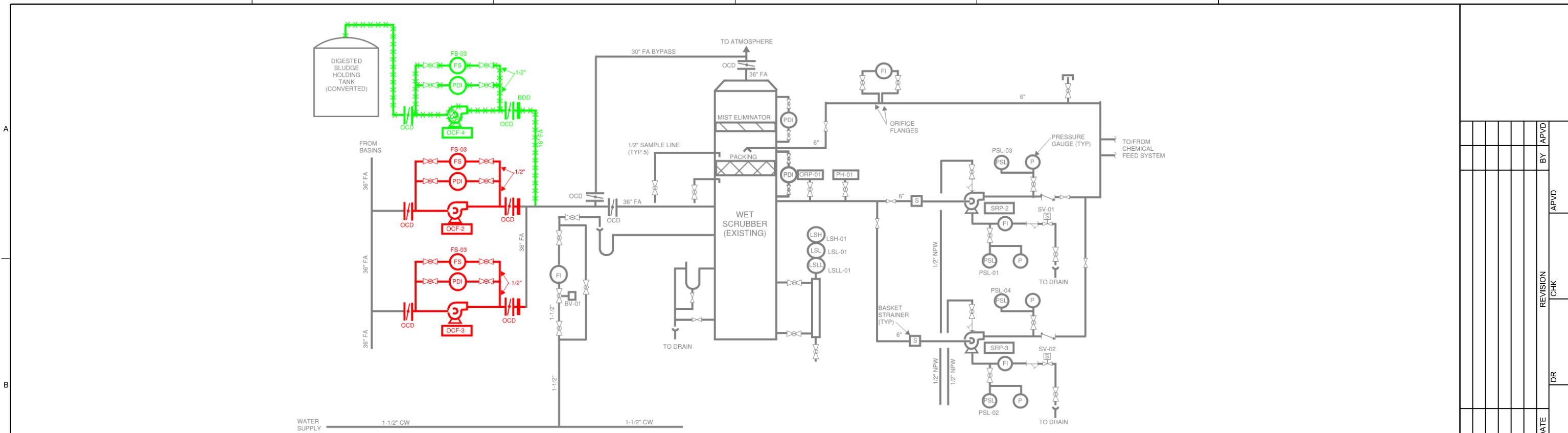
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MOVE EQUIPMENT TO
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PERIMETER



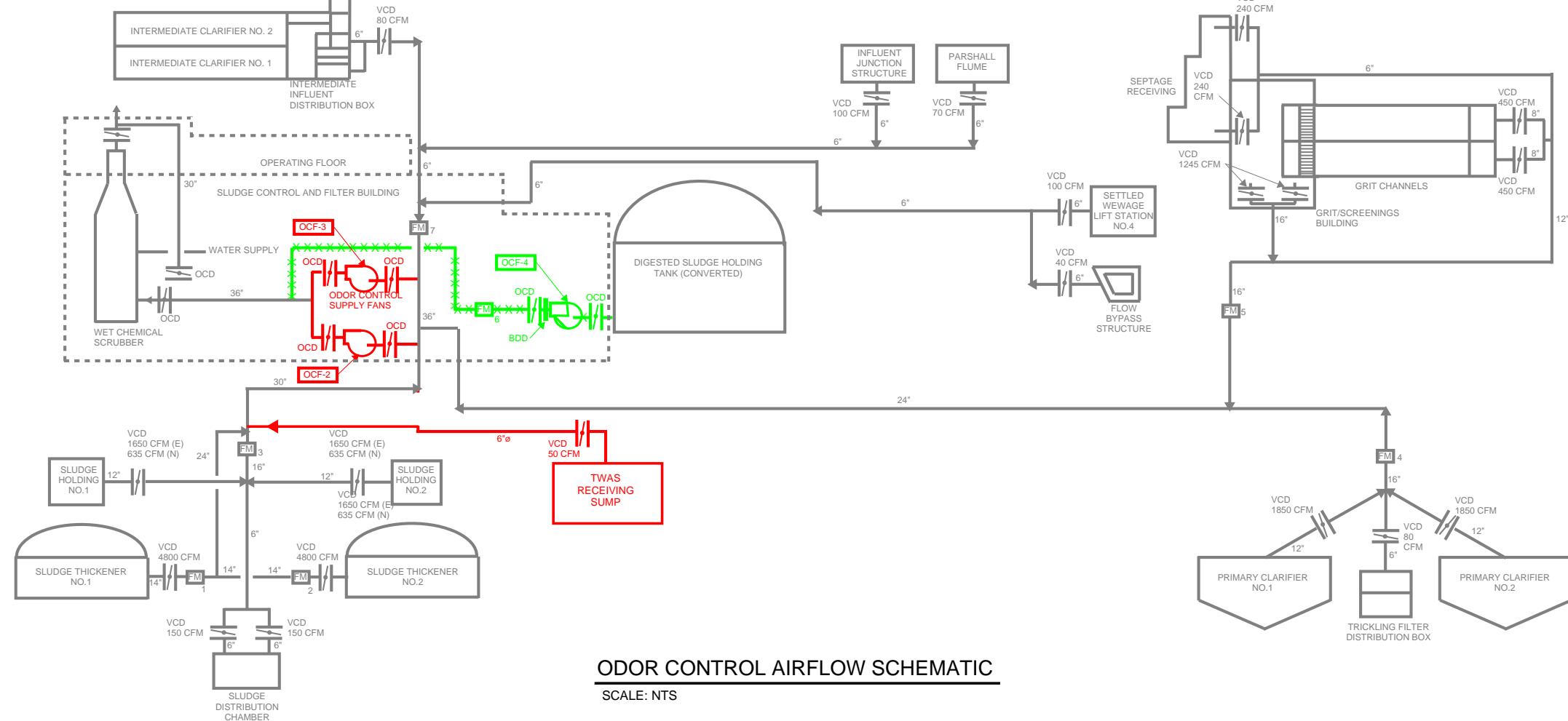
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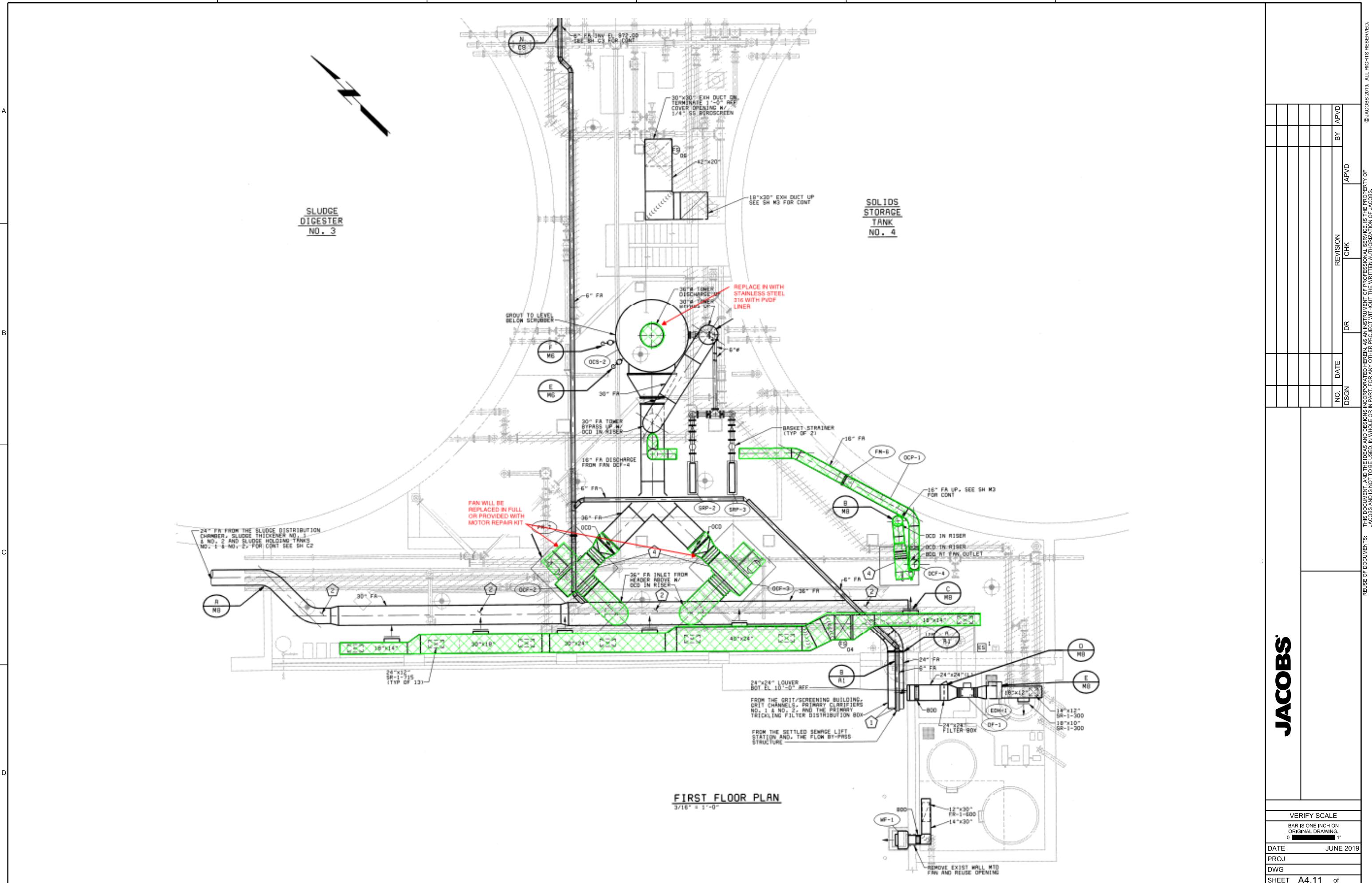


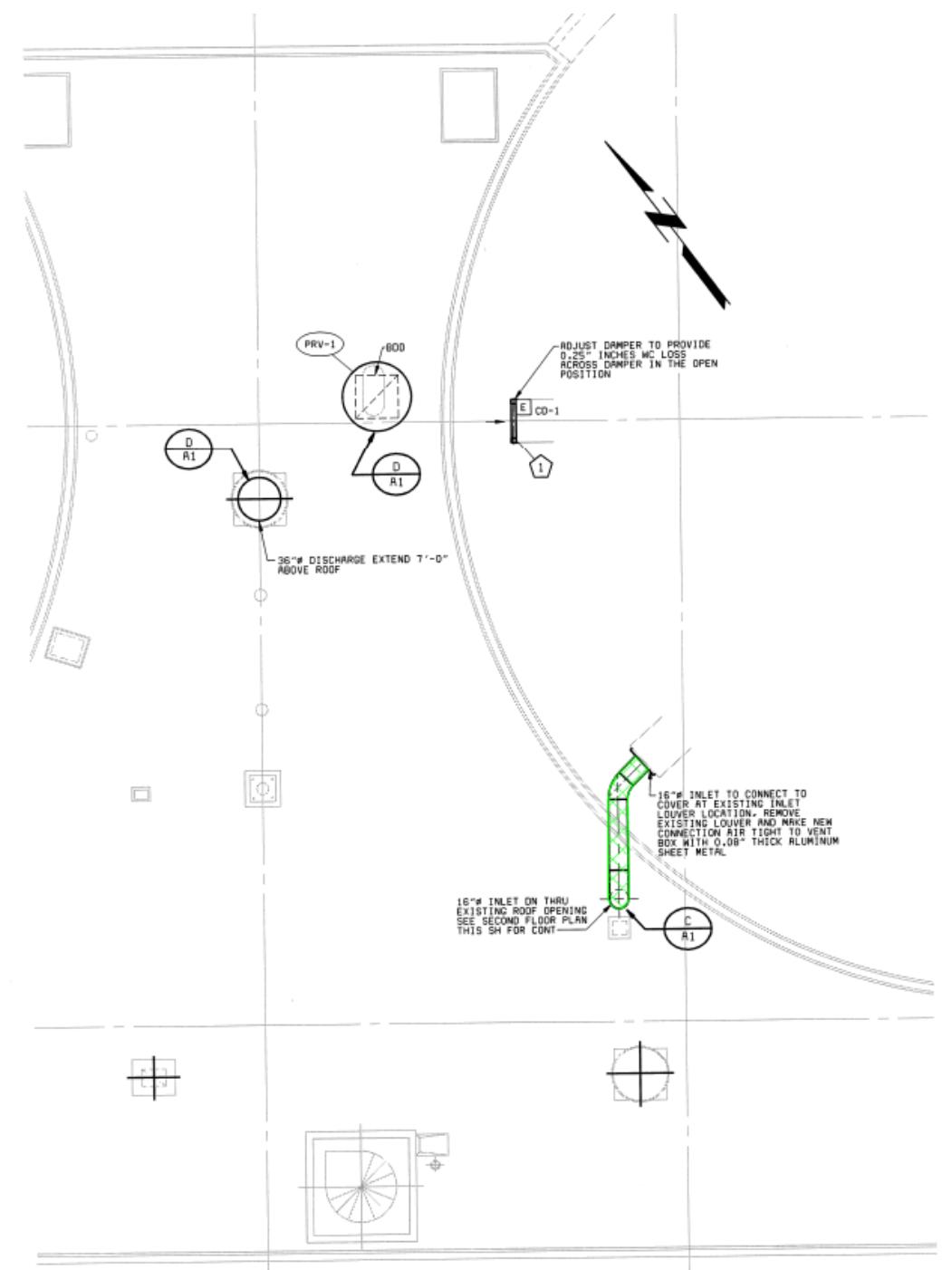
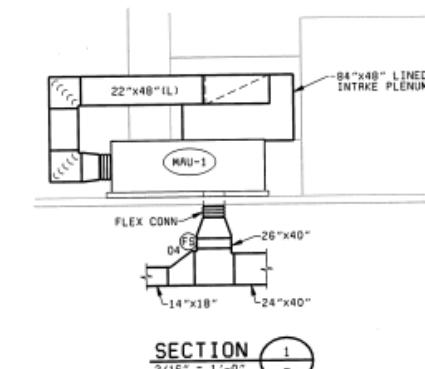
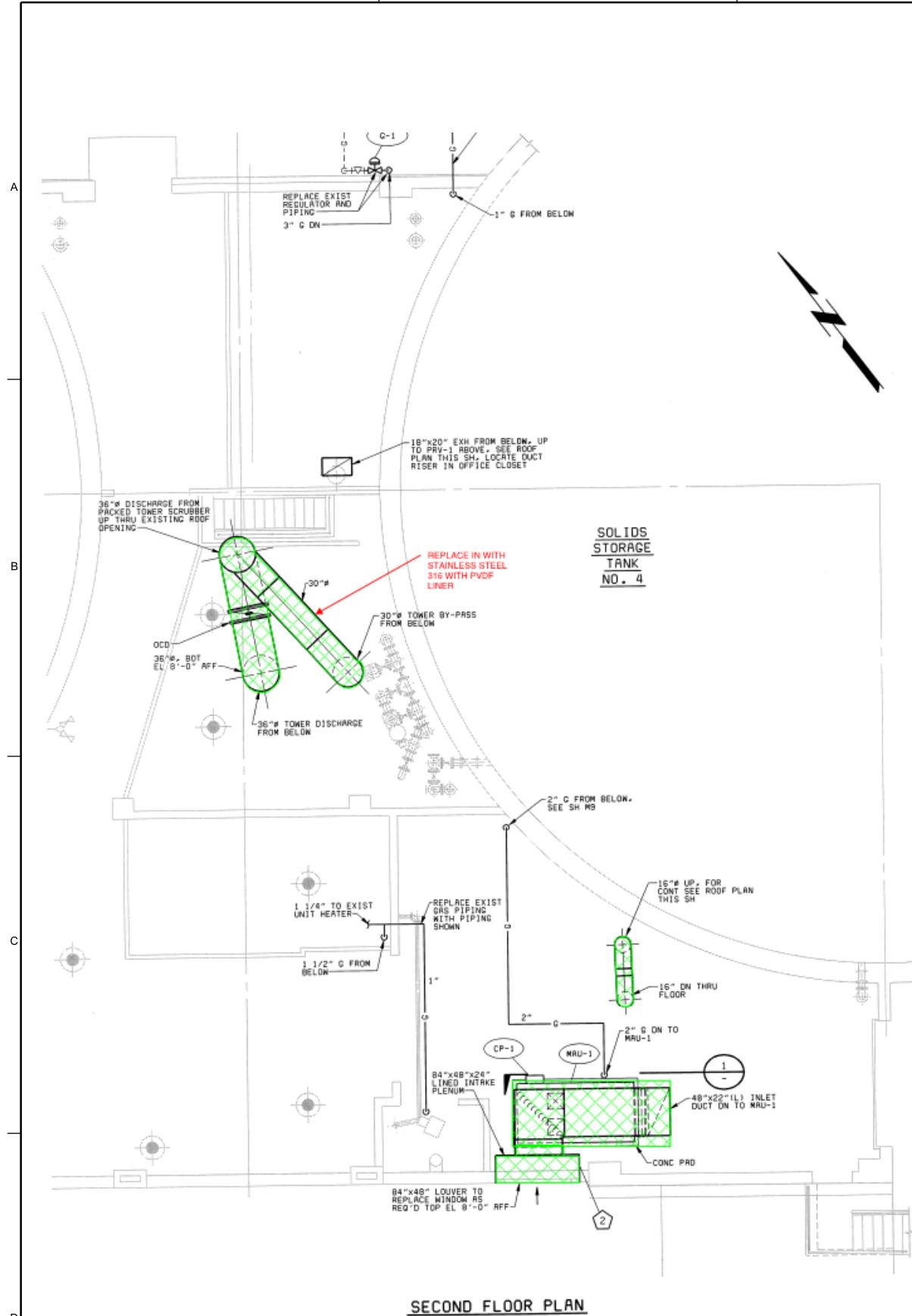
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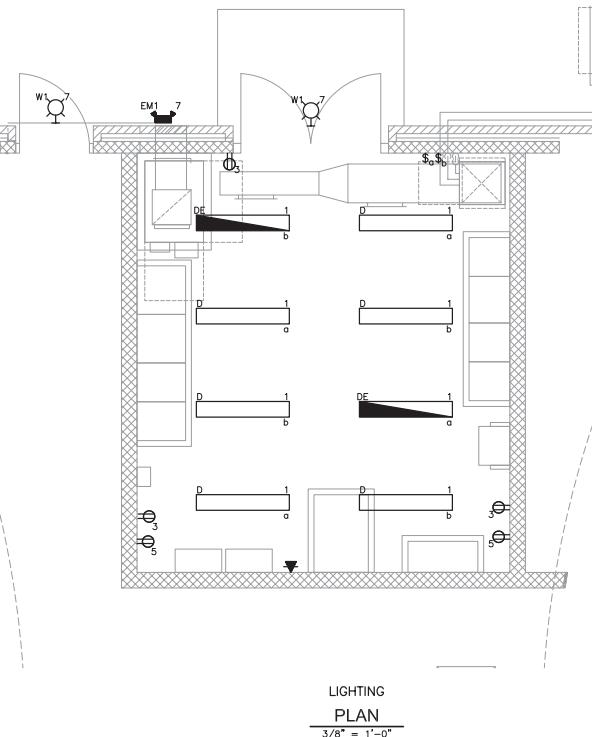
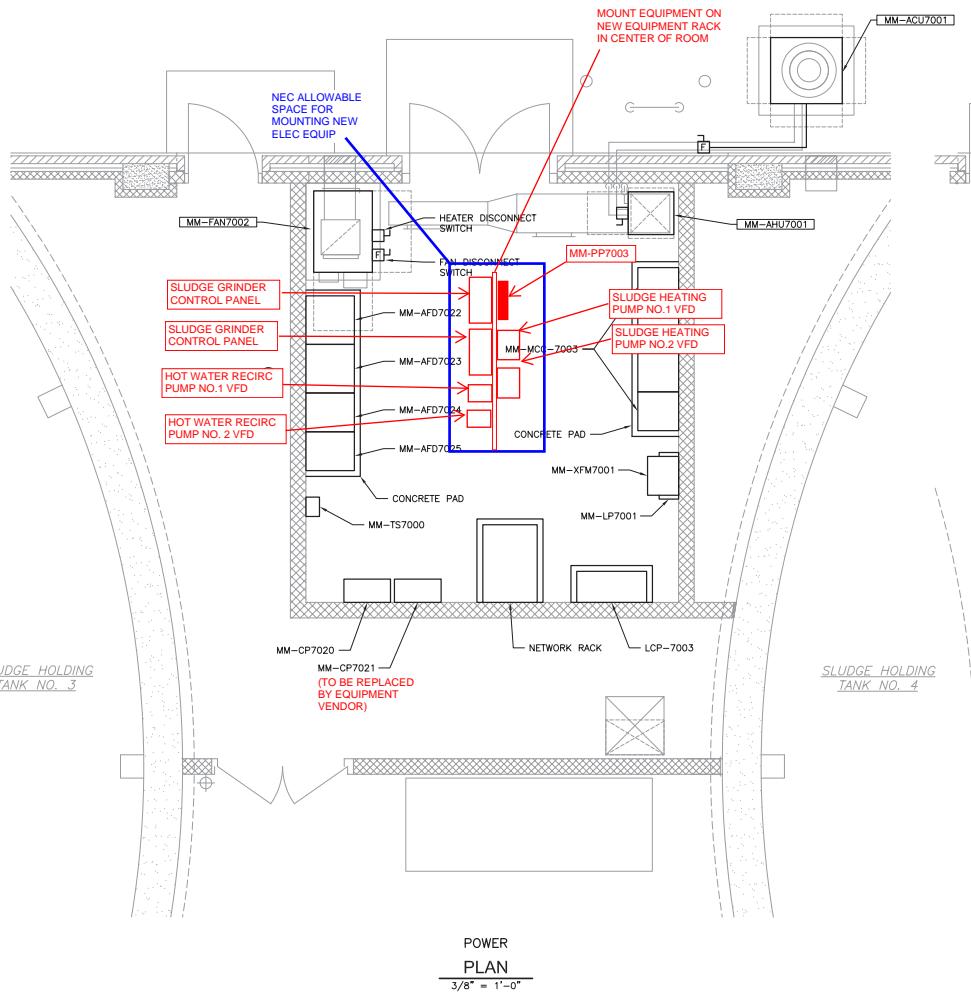
APPENDIX A5

ELECTRICAL

images: □

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**LIGHTING
PLAN**

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By *[Signature]* Date 12/2018
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10/15	KR	B.F.	ISSUED CONFORMED SET PER ADDENDA'S 1 THRU 7		APPROVED
REV. NO.	DATE	DRWN	CHKD	REMARKS	DATE:

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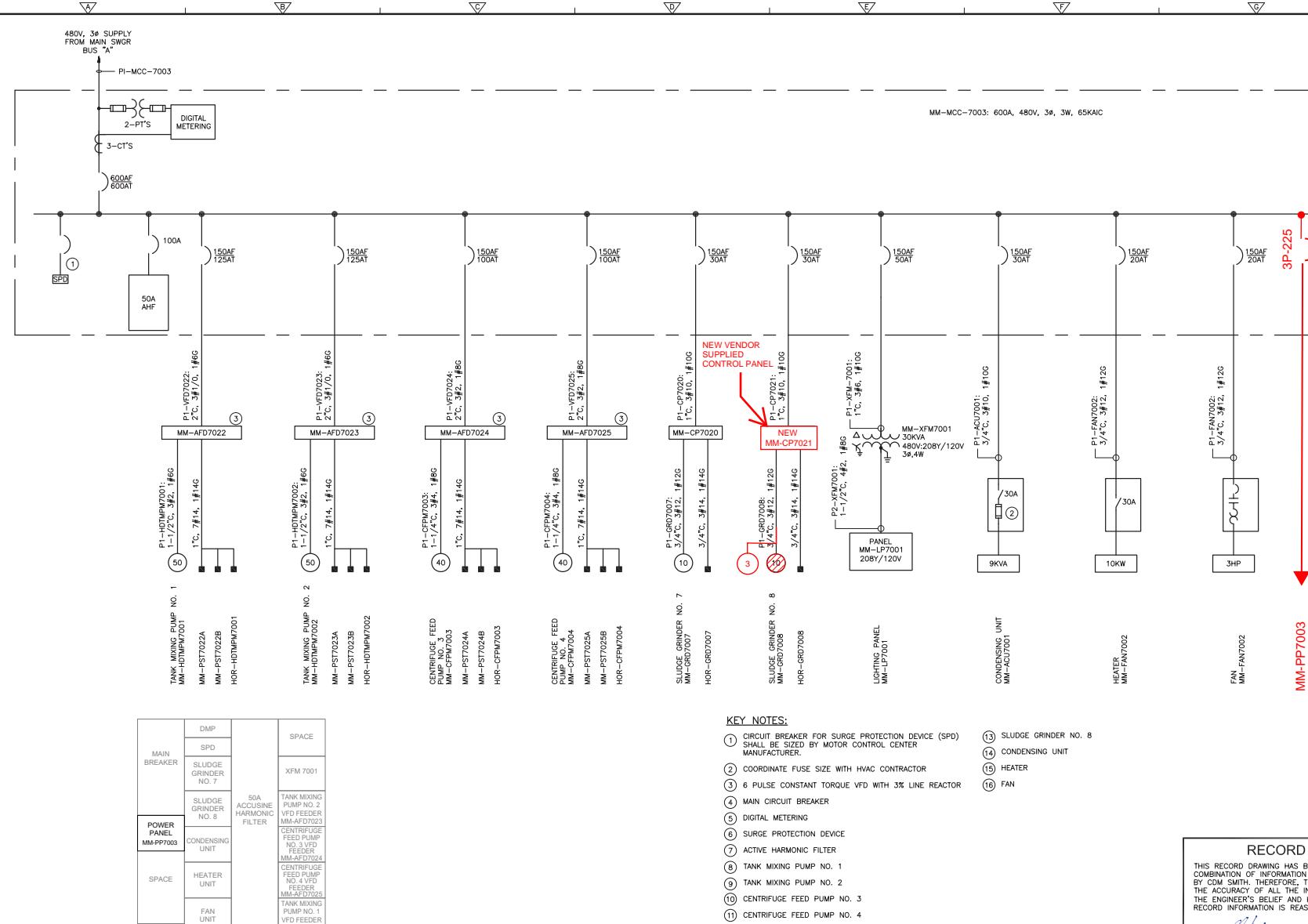
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JOHNSON COUNTY WASTEWATER
JCW CONTRACT NO.20 (CMSD-C020)
NELSON COMPLEX WWTP
SOLIDS HANDLING IMPROVEMENTS PROJECT

BUILDING NO.3
ELECTRICAL ROOM POWER & LIGHTING PLAN
EE FL 975.74

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FILE NAME: E021ELPP.D
SHEET NO.
03E101
A5 1



KEY NOTES:

- ① CIRCUIT BREAKER FOR SURGE PROTECTION DEVICE (SPD) SHALL BE SIZED BY MOTOR CONTROL CENTER MANUFACTURER.
- ② COORDINATE FUSE SIZE WITH HVAC CONTRACTOR
- ③ 6 PULSE CONSTANT TORQUE VFD WITH 3% LINE REACTOR
- ④ MAIN CIRCUIT BREAKER
- ⑤ DIGITAL METERING
- ⑥ SURGE PROTECTION DEVICE
- ⑦ ACTIVE HARMONIC FILTER
- ⑧ TANK MIXING PUMP NO. 1
- ⑨ TANK MIXING PUMP NO. 2
- ⑩ CENTRIFUGE FEED PUMP NO. 3
- ⑪ CENTRIFUGE FEED PUMP NO. 4
- ⑫ SLUDGE GRINDER NO. 7
- ⑬ SLUDGE GRINDER NO. 8
- ⑭ CONDENSING UNIT
- ⑮ HEATER
- ⑯ FAN

MM-PP7003

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NEW MCC-7003
ONE LINE DIAGRAM

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FILE NAME: E0070LDB.DWG

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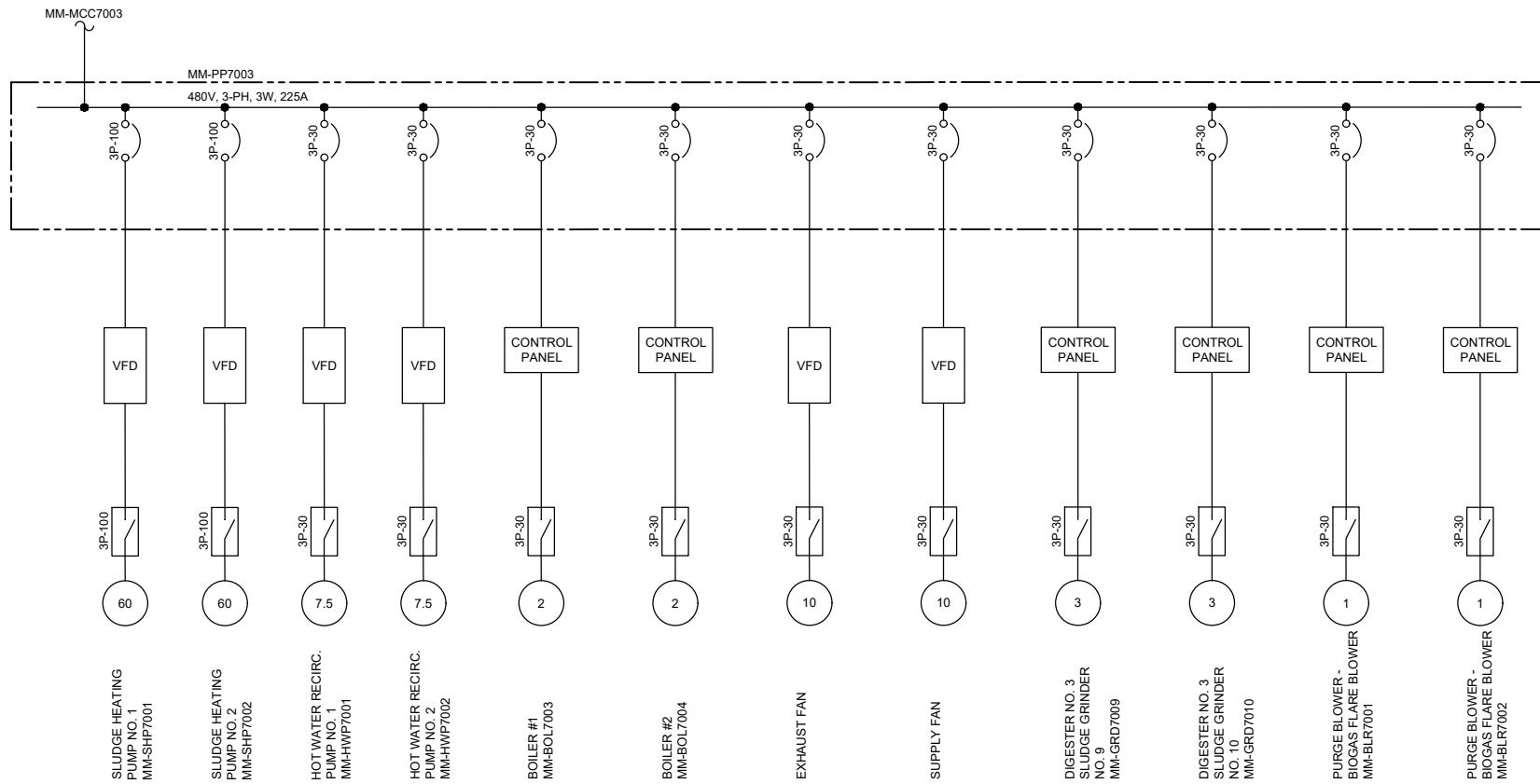
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1	09/18 KBR	DLC	ISSUED CONFORMED SET PER ADDENDA'S 1 THRU 7	REVISION NO.	DATE DRWN CHKD
					REMARKS



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JOHNSON COUNTY WASTEWATER
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SOLIDS HANDLING IMPROVEMENTS PROJECT



ch2m

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CIVIL					
STRUCTURAL					
ARCHITECTURAL					
PROCESS					
MECHANICAL					
ELECTRICAL					
INSTRUMENTATION					
PROJECT NUMBER 10052145					
ISSUE	DATE	DESCRIPTION			

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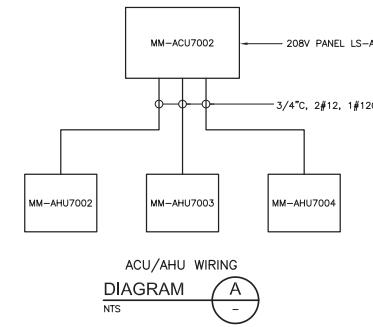
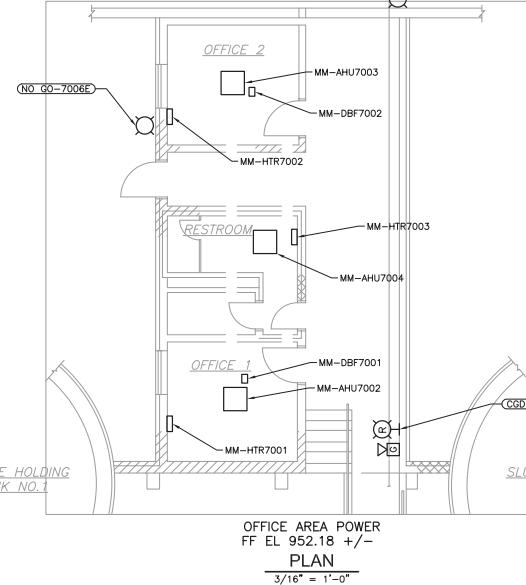
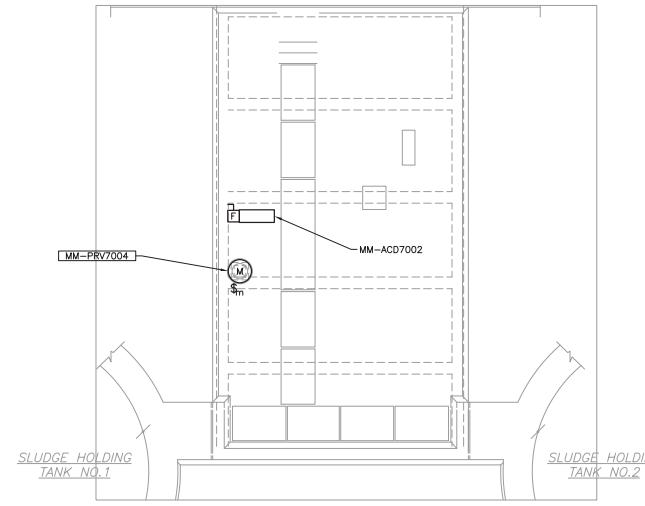
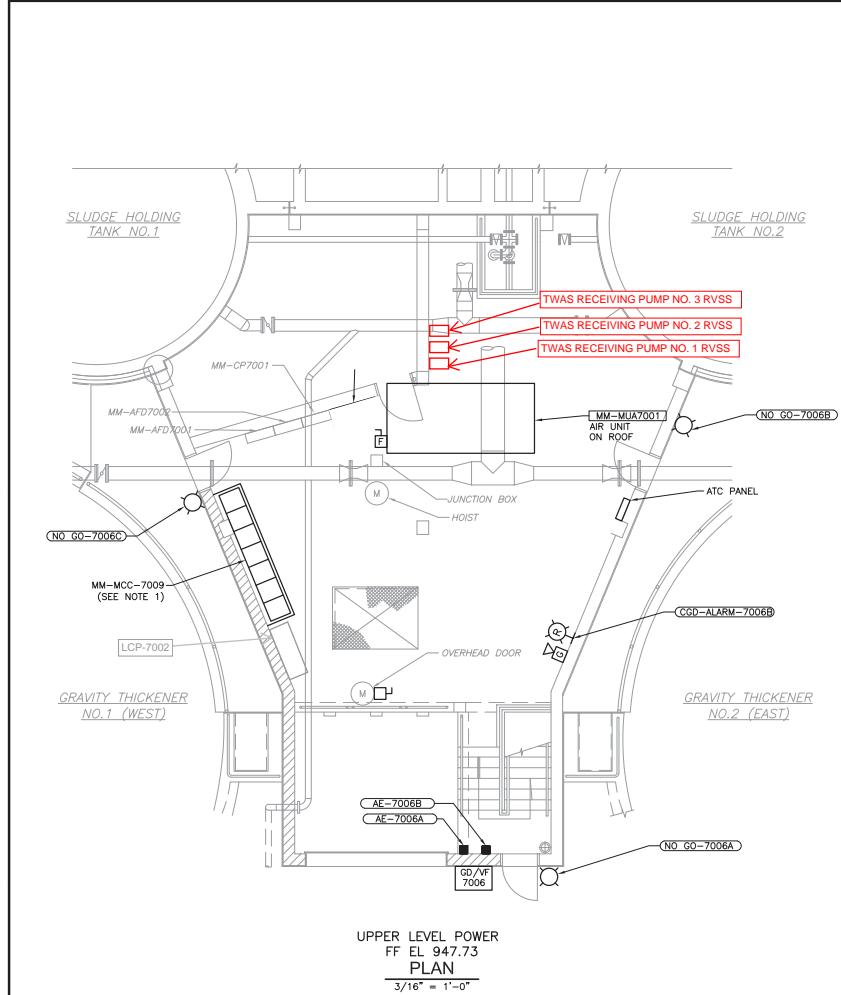


JOHNSON COUNTY WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028

BUILDING NO. 3
MM-PP7003 ONE-LINE DIAGRAM

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SCALE NTS
FILENAME 03E602.dwg

SHEET
03E602
A5.3



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By *M.L.S.* Date 12/2018
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BUILDING NO.9
UPPER LEVEL & OFFICE AREA
POWER PLAN

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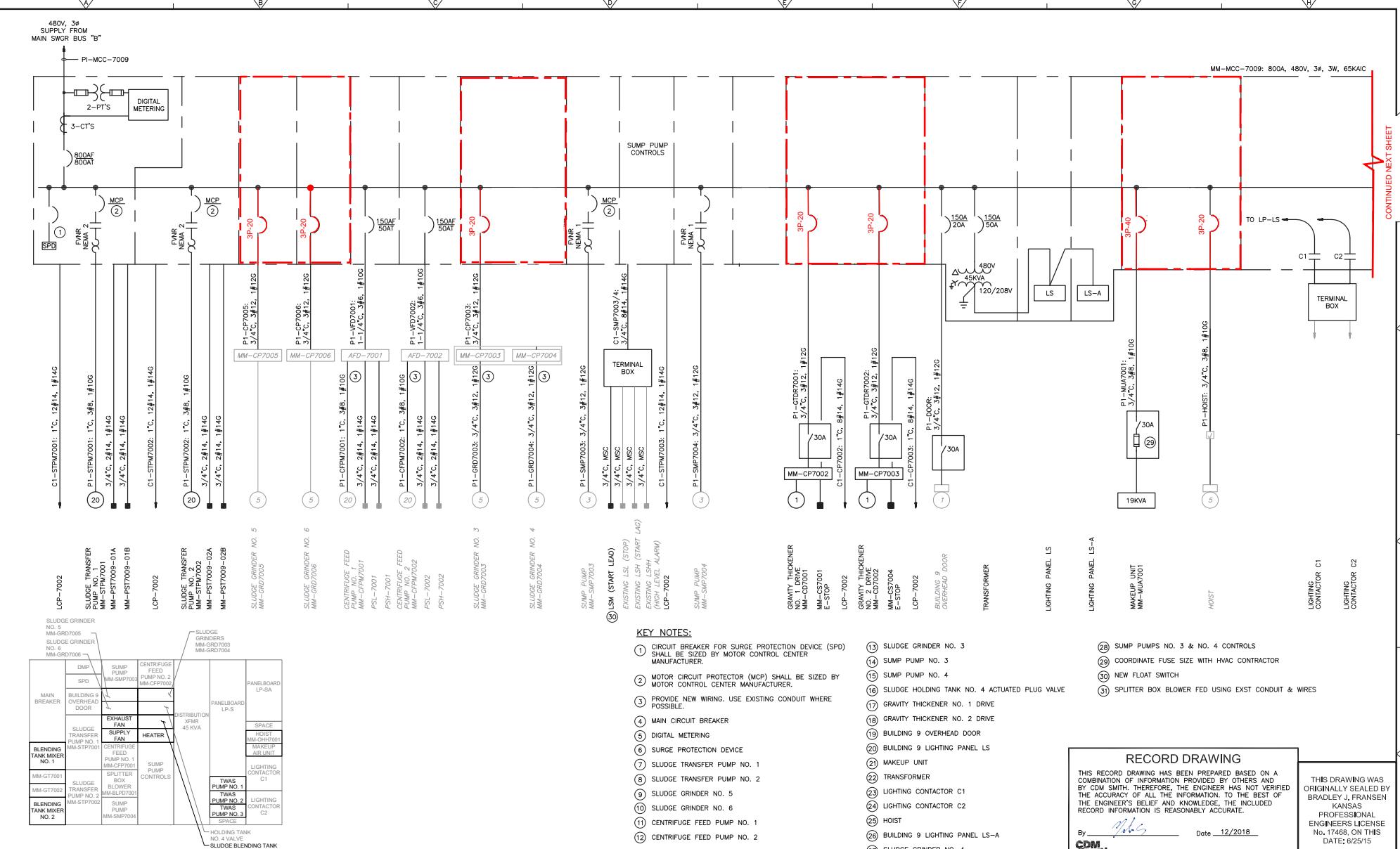
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1	09/18	KBR	DLC	BJF	REVISED PER THE RECORD ISSUED CONFORMED SET PER ADDENDA'S 1 THRU 7											JUNE 2015

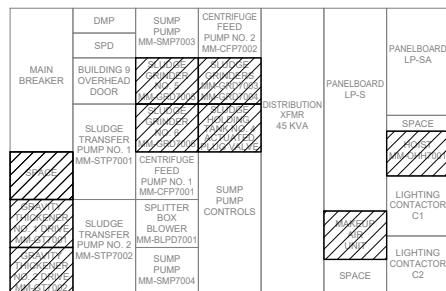
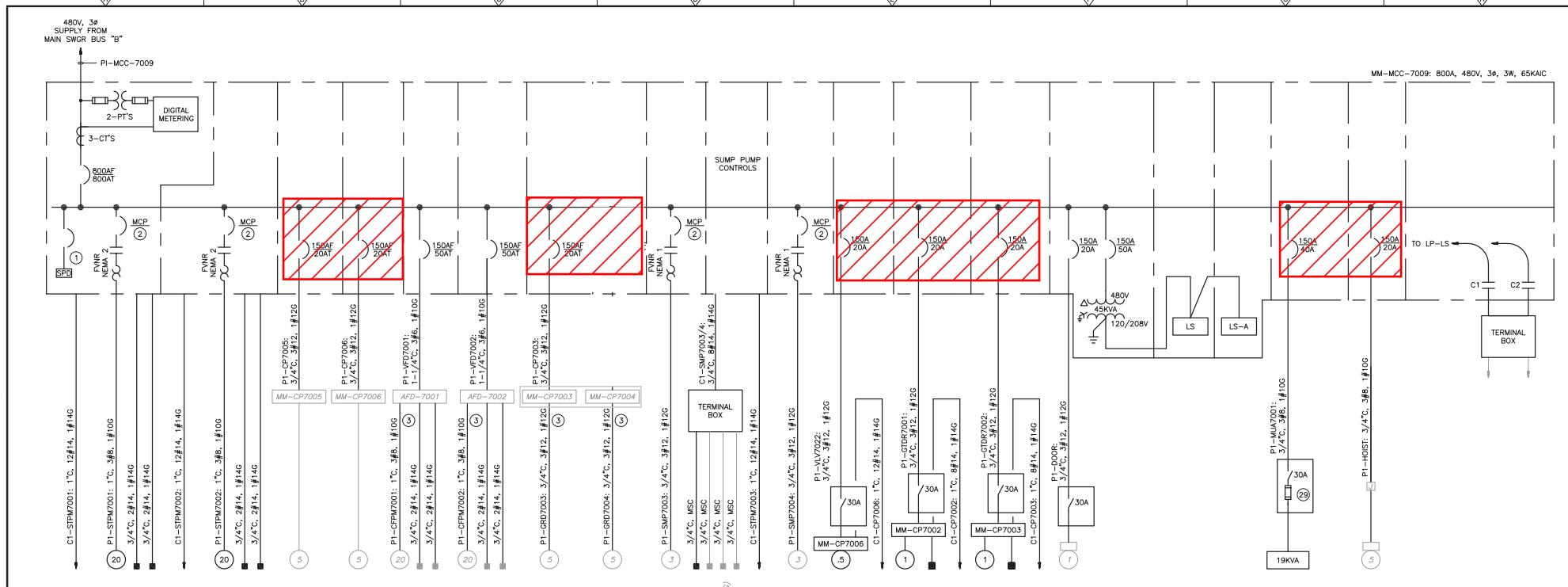
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JOHNSON COUNTY WASTEWATER
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 NELSON COMPLEX WWTP
 SOLIDS HANDLING IMPROVEMENTS PROJECT

PROJECT NO. 10936-106556
 FILE NAME: E019PPGT.DWG
 SHEET NO.
09E101





KEY NOTES:

- ① CIRCUIT BREAKER FOR SURGE PROTECTION DEVICE (SPD) SHALL BE SIZED BY MOTOR CONTROL CENTER MANUFACTURER.
- ② MOTOR CIRCUIT PROTECTOR (MCP) SHALL BE SIZED BY MOTOR CONTROL CENTER MANUFACTURER.
- ③ PROVIDE NEW WIRING, USE EXISTING CONDUIT WHERE POSSIBLE.
- ④ MAIN CIRCUIT BREAKER
- ⑤ DIGITAL METERING
- ⑥ SURGE PROTECTION DEVICE
- ⑦ SLUDGE TRANSFER PUMP NO. 1
- ⑧ SLUDGE TRANSFER PUMP NO. 2
- ⑨ SLUDGE GRINDER NO. 5
- ⑩ SLUDGE GRINDER NO. 6
- ⑪ CENTRIFUGE FEED PUMP NO. 1
- ⑫ CENTRIFUGE FEED PUMP NO. 2
- ⑬ SLUDGE GRINDER NO. 3
- ⑭ SLUMP PUMP NO. 3
- ⑮ SLUMP PUMP NO. 4
- ⑯ SLUDGE HOLDING TANK NO. 4 ACTUATED PLUG VALVE
- ⑰ GRAVITY THICKENER NO. 1 DRIVE
- ⑱ GRAVITY THICKENER NO. 2 DRIVE
- ⑲ BUILDING 9 OVERHEAD DOOR
- ⑳ BUILDING 9 LIGHTING PANEL LS
- ㉑ MAKEUP UNIT
- ㉒ TRANSFORMER
- ㉓ LIGHTING CONTACTOR C1
- ㉔ LIGHTING CONTACTOR C2
- ㉕ HOIST
- ㉖ BUILDING 9 LIGHTING PANEL LS-A
- ㉗ SLUDGE GRINDER NO. 4

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BUILDING NO. 9
MCC-7009
ONE LINE DIAGRAM DEMOLITION

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FILE NAME: E0060LGT.DWG
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			KBR	DLC	BJF	
09/18/15	10/15		ISSUED CONFORMED SET PER ADDENDA'S 1 THRU 7			

DESIGNED BY: <u>M. KOPEC</u>	DRAWN BY: <u>M. KOPEC</u>
SHEET CHKD BY: <u>A. THOMPSON</u>	CROSS CHKD BY: <u>B. YOUNG</u>
APPROVED BY: <u>B. FRANSSEN</u>	DATE: <u>JUNE 2015</u>

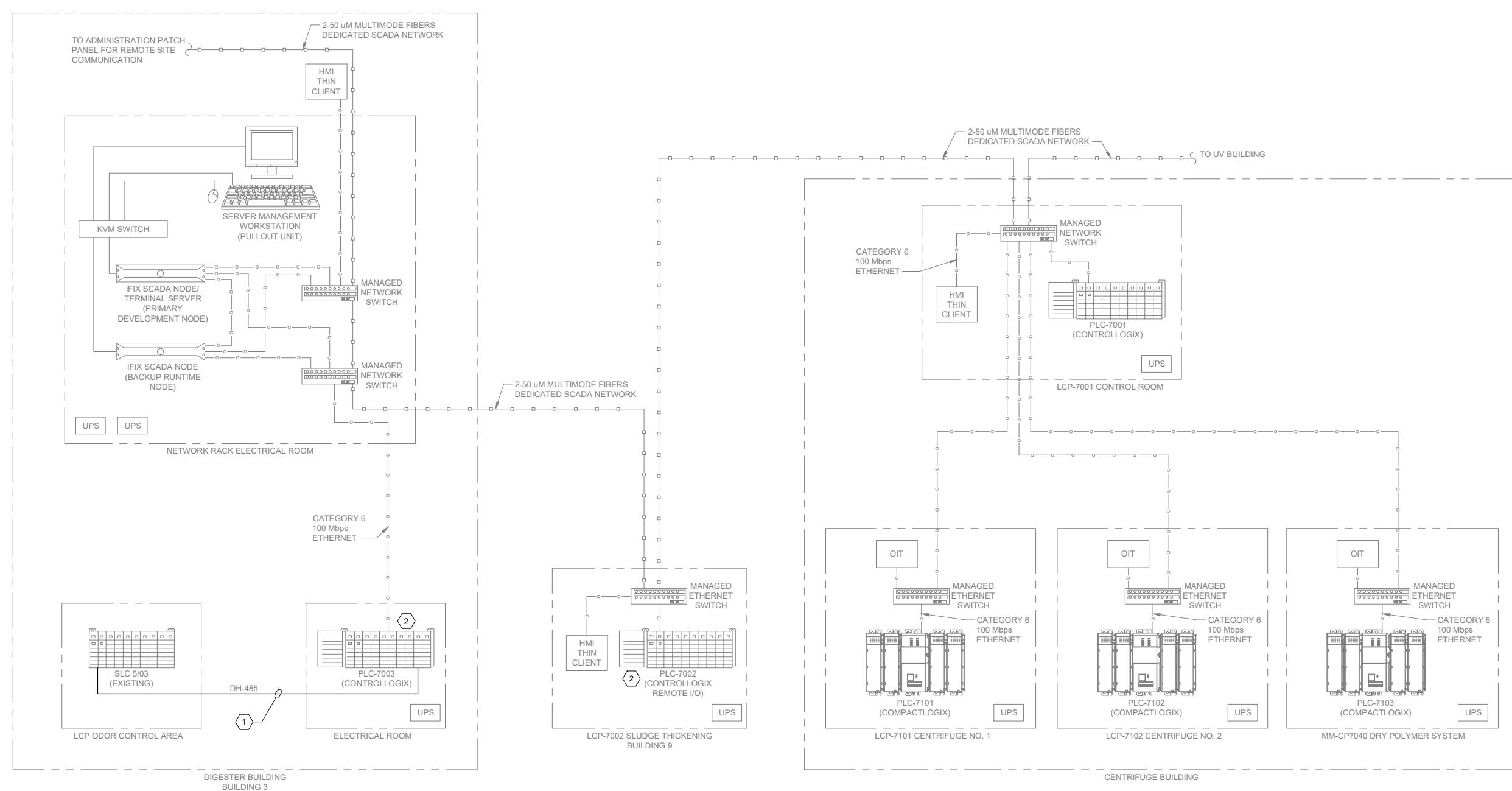


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JOHNSON COUNTY WASTEWATER
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APPENDIX A6

INSTRUMENTATION AND CONTROL



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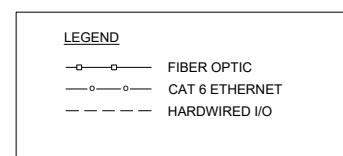
HDR
KANSAS CERTIFICATE OF
Authority # 000856

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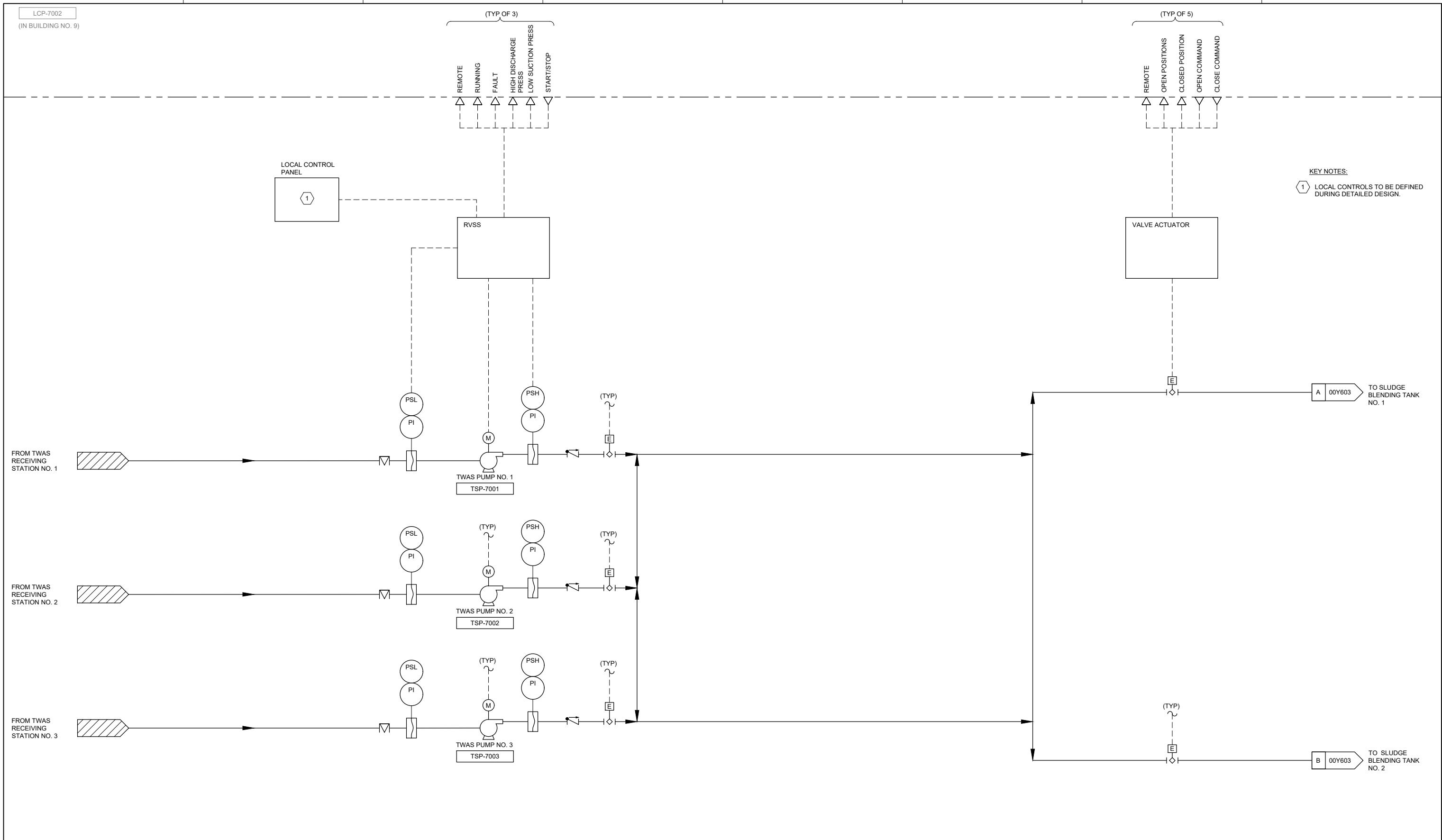


**JOHNSON COUNTY
WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028**



SCADA SYSTEM ARCHITECTURE

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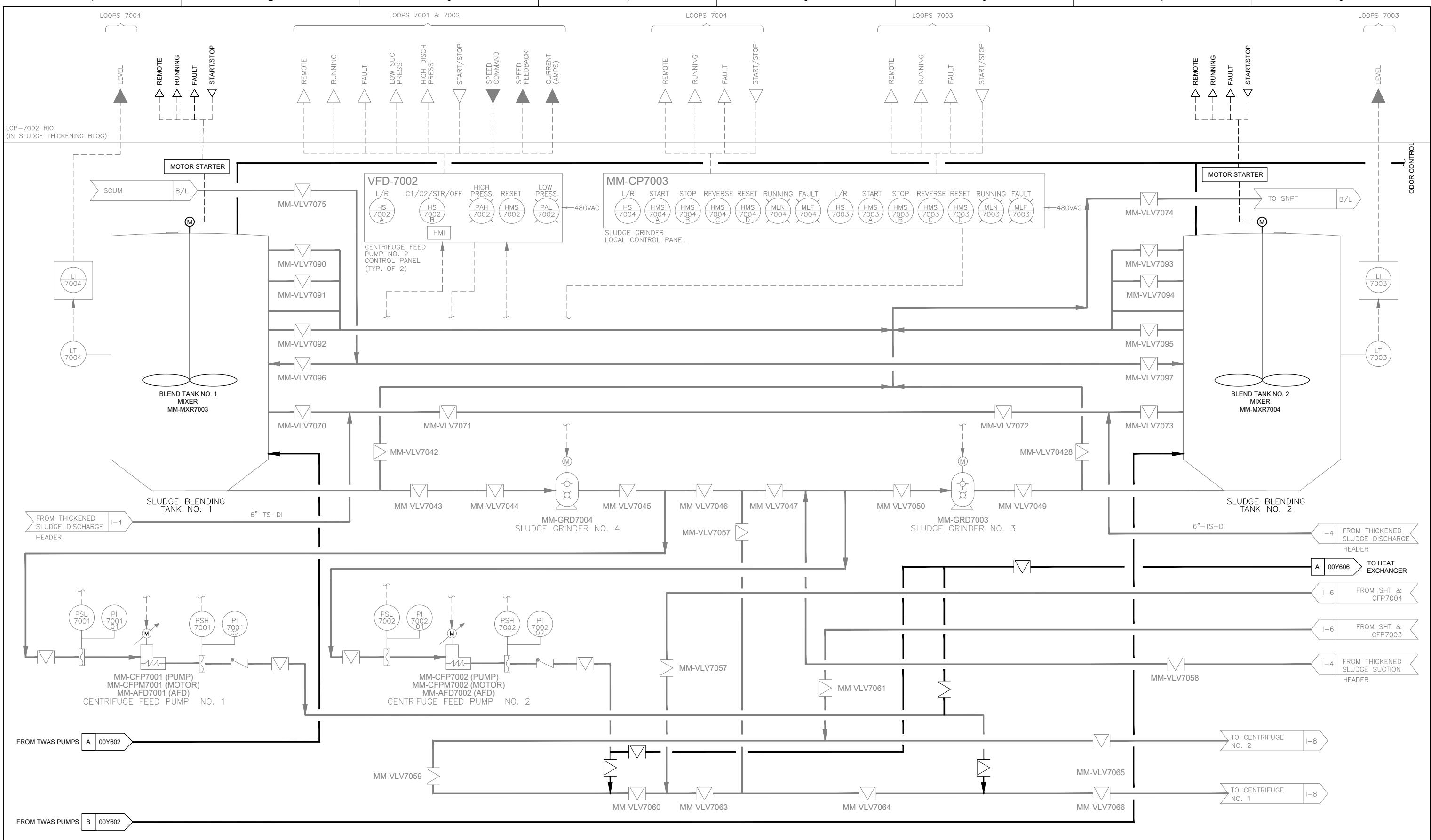
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WASTEWATER
KANSAS
Wastewater

JOHNSON COUNTY
WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028

PROCESS AND INSTRUMENTATION DIAGRAM
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SCALE NTS

SHEET 00Y602 A6.2



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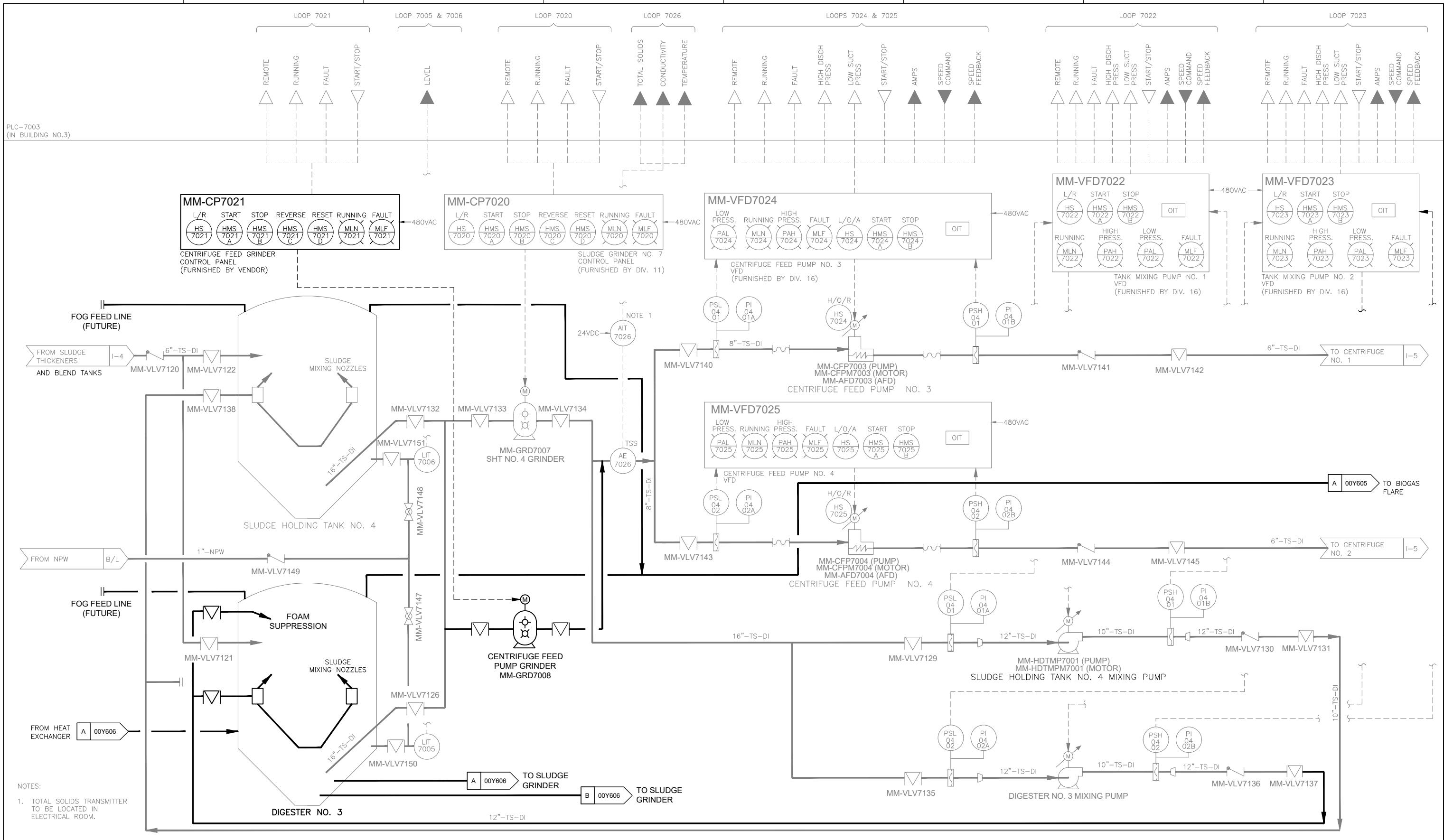


**JOHNSON COUNTY
WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028**

PROCESS AND INSTRUMENTATION DIAGRAM SLUDGE BLENDING TANKS 1 AND 2



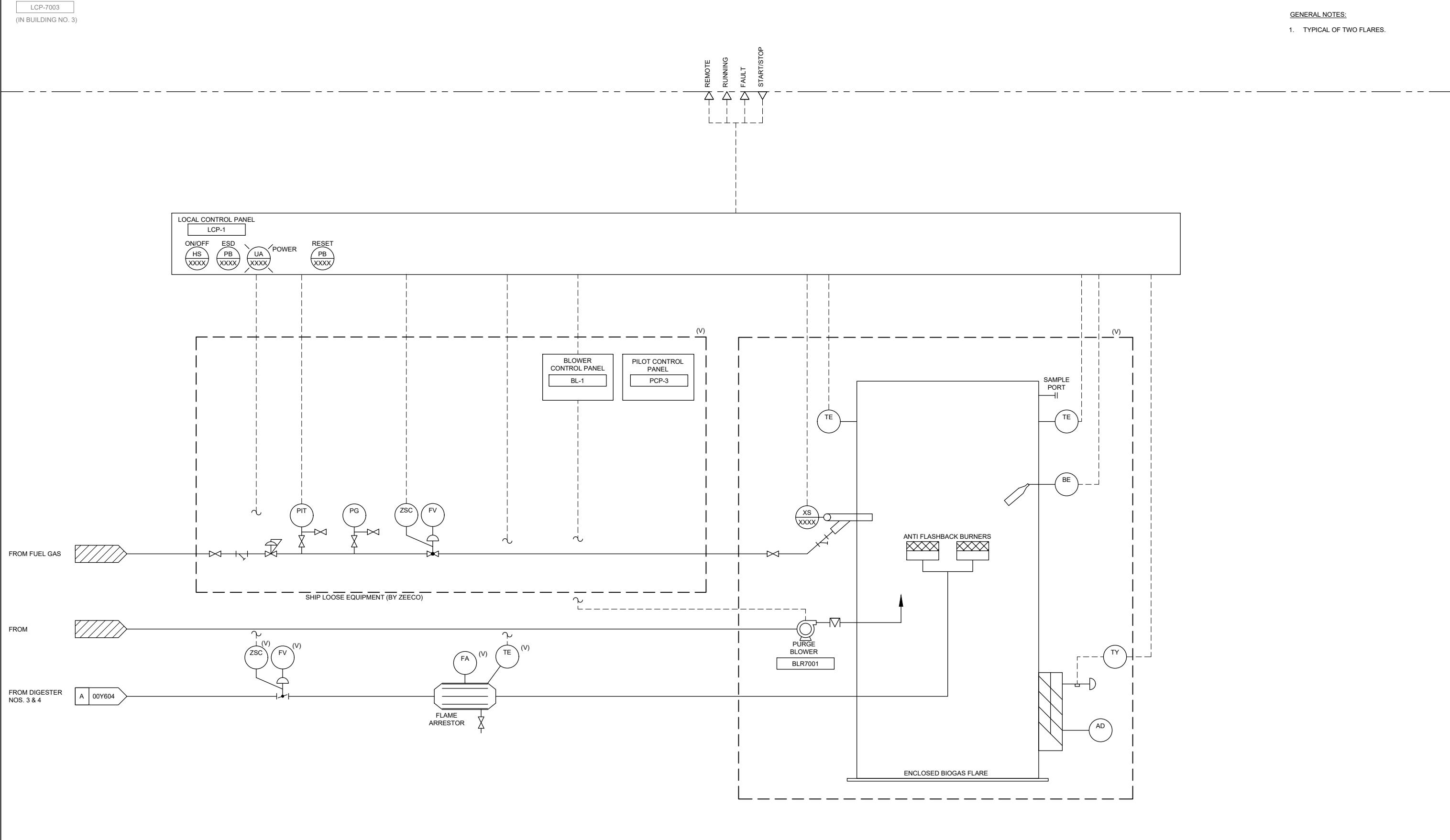
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LCP-7003
(IN BUILDING NO. 3)

GENERAL NOTES:

- ## 1. TYPICAL OF TWO FLARES.



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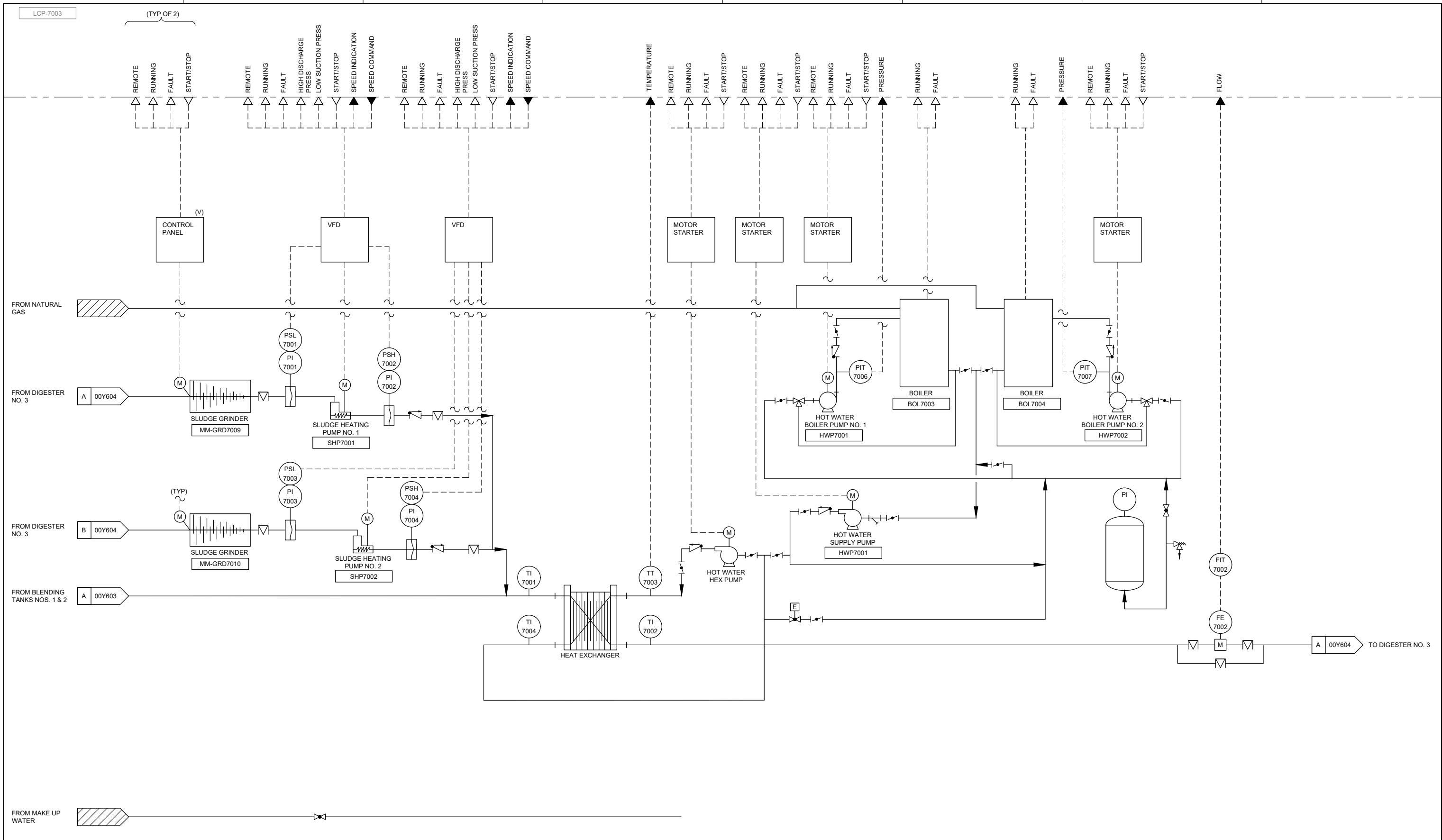
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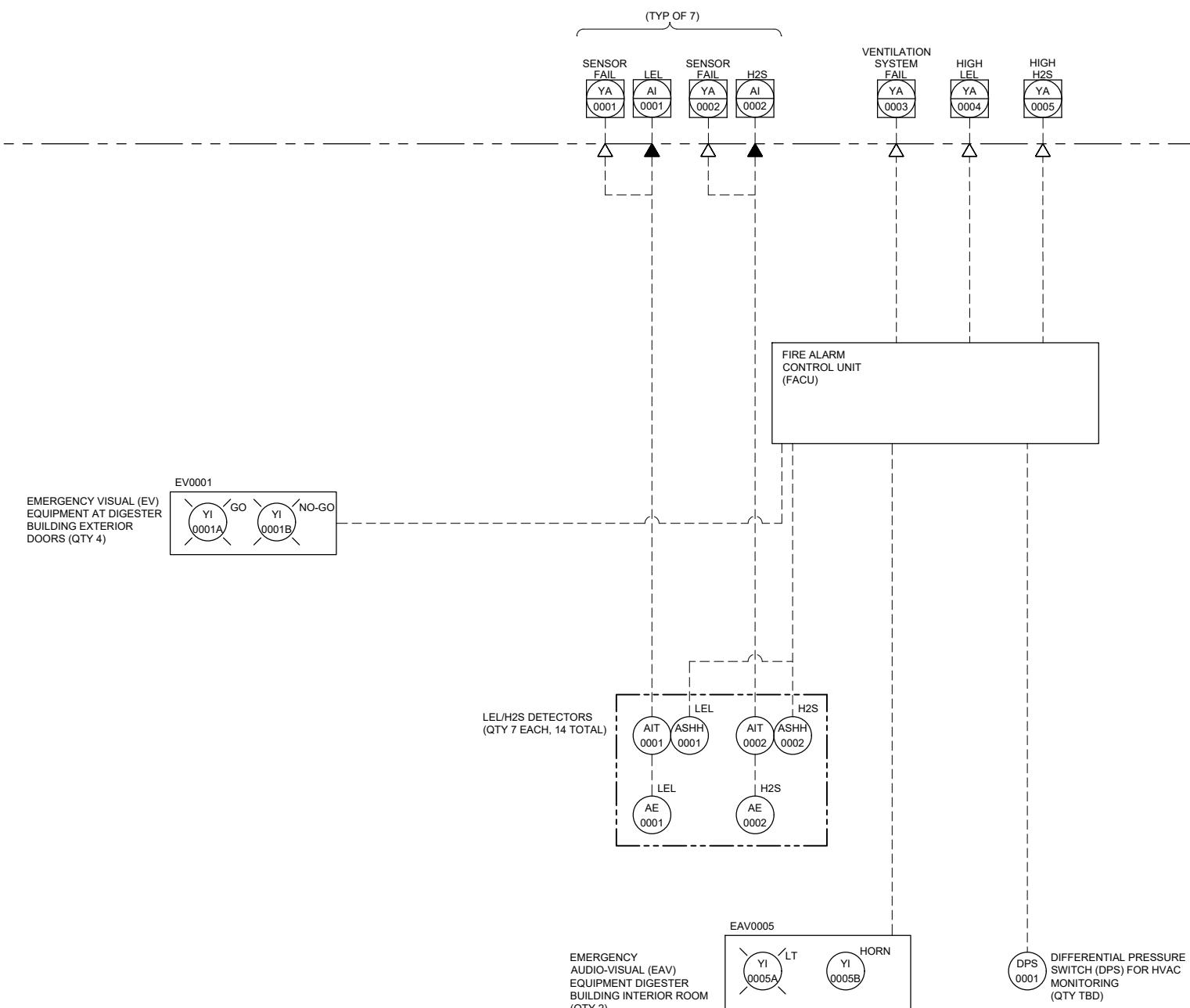
**JOHNSON COUNTY
WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD - C028**

PROCESS AND INSTRUMENTATION DIAGRAM BIOGAS FLARE DIGESTER

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LCP-7003
(IN BUILDING NO. 3)



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	ARCHITECTURAL	
	PROCESS	
	MECHANICAL	
	ELECTRICAL	
	INSTRUMENTATION	
ISSUE	DATE	DESCRIPTION
PROJECT NUMBER	10052145	

**PRELIMINARY
NOT FOR
CONSTRUCTION
OR
RECORDING**



**JOHNSON COUNTY
WASTEWATER
NELSON BIOSOLIDS
FACILITIES - PHASE 1A
CMSD C028**

PROCESS AND INSTRUMENTATION DIAGRAM HAZARDOUS GAS DETECTION

SHEET
00Y607

APPENDIX B

LABORATORY TESTING

Laboratory Testing

TEMPERATURE

Microorganisms involved in the anaerobic digestion process are most active at temperatures between 85 and 135° F (29 to 57° C). For economic reasons, most digesters are designed to operate at a mesophilic temperature between 86 and 104° F (30 to 40° C). The anaerobic microorganisms, especially methanogens, are highly sensitive to changes in temperature and, therefore, require the temperature to remain constant or be changed very slowly (not more than 1.5°F per day).

AMMONIA - NITROGEN

Ammonia-N is product of the digestion of organic material. High concentrations of ammonia-N are commonly observed in digestion. In digesters processing primarily municipal sludge it is common to see ammonia-N concentrations between 1,000 mg and 1,500 mg-N/L. Ammonia-N concentrations above 1,500 mg-N/L can lead to moderate inhibition in the digestion process, with concentrations above 4,000 mg-N/L providing substantial inhibition.

PH

The anaerobic digestion process continually produces acids as part of the transformation of organic matter. In a well operating digester acid production is offset by alkalinity produced by methanogenesis. However, a process upset that reduces the amount of alkalinity available may result in acidic conditions.

One of the most important requirements is the maintenance of a neutral pH. Standard mesophilic anaerobic digestion proceeds well in the range of pH 6.8 to 7.2. At pH values below 6.8, the digester efficiency may drop off rapidly, and the acidic conditions produced can quickly inhibit methanogenesis.

pH is generally not a good control parameter, as a pH change is usually not detected until the buffering capacity (alkalinity) has been consumed, which may not occur until the digestion process is already damaged. However, it is an easily performed test, and is useful for confirming the digester condition. For a digester with an operating problem, the pH test may be used as a guide when neutralization of excess acid is a part of the corrective treatment. Normally, the maximum beneficial effect of chemical addition is obtained when adjusting the pH to 6.8 or slightly higher.

ALKALINITY

Alkalinity represents the process's ability to buffer changes in pH. Alkalinity is continually produced through digestion in the form of dissolved carbon dioxide (CO_2) from methanogenesis and ammonia production through the degradation of organic matter.

As with pH, alkalinity is an important parameter to monitor in the digestion and a better indicator of an impending process upset. Downward trends in alkalinity suggest acid production that is consuming alkalinity. Alkalinity measurements alone are not typically enough to indicate a process upset but can be used in conjunction with pH and volatile acid production to assess the health of the digestion process. In a well operating digestion process, it is typically desired to observe alkalinity concentrations above 4,500 mg CaCO_3/L .

VOLATILE FATTY ACIDS

Volatile fatty acids (VFA) are a group of short chain carbon compounds and the primary

intermediates between the organic matter entering the digester and methane production.

Monitoring of VFAs can provide valuable information regarding the health of the digestion process.

The total concentration of VFAs provides an indication of how complete digestion is. The target total VFA concentration is specific to each digester, but generally total VFA concentrations between 50 and 300 mg/L are considered normal for mesophilic digesters. An increase in volatile acids indicates an upset of the balance between the acid-forming and methane-forming bacteria. Temperature and ammonia concentrations can also impact the operating VFA concentration. Monitoring the specific VFAs provides more insight into digester health.

Specifically, increases in propionic and butyric acids can indicate the onset of a process upset.

The advantage of using the volatile acids determination lies in the fact that the onset of unfavorable conditions can be detected relatively early into a process upset, rather than after several days, as in the case of the pH.

VOLATILE ACID-ALKALINITY RATIO

The volatile acid-alkalinity ratio is the most reliable indicator of an impending problem. The ratio is a better indicator than volatile acids concentration alone as under some circumstances, an increase in volatile acids may be accompanied by a neutralizing increase in alkalinity. By performing a total alkalinity test at the same time and on the same sample used for the volatile acids test, the ratio of volatile acids-to-alkalinity may be obtained. In a stable digester, this value is within a range of 0.3 to 0.1 or less. A steady trend to a higher than normal ratio indicates that an unsatisfactory condition is beginning to develop.

VOLATILE SOLIDS

Volatile Solids (VS) is the measurement of the ignitable fraction of the total solids entering the digester, which represents the organic fraction of the solids. The VS measurement does not represent the amount of biodegradable material, but it is the most common measurement of the digester substrate. VS is typically measured on the digester feed sludge and on the digested sludge to track the amount of volatile solids reduction (VSR) that is occurring. The VSR for typical municipal sludges ranges from 45 to 55 percent. Trends in decreasing VSR can indicate a process upset.

CHEMICAL OXYGEN DEMAND

Chemical oxygen demand (COD) indicates the amount of oxidizable material in the solids and can be utilized to monitor substrate utilization, similar to VSR.

GAS PRODUCTION

If the amount of sludge fed to the digesters each day is held relatively constant, the microorganisms utilize the organic matter at a constant rate, resulting in a relatively constant volume of daily gas production. Biogas is typically reported as the amount of gas produced relative to the amount of volatile solids reduced (e.g. cubic feet/pound of volatile solids reduced), with normal values ranging near 20-25 cubic feet/pound of volatile solids destroyed. A decrease in gas production indicates that the activity of the microorganisms has been reduced by a decrease in sludge organic content or a changed digester environment. An increase in daily gas production generally indicates that: (1) the organic feed rate has increased, (2) the microorganism population is increasing, or (3) digestion efficiency is increasing.

BIOGAS CONTENT

Monitoring of biogas content is also important to characterize the health of the digestion process. Methane (CH_4), carbon dioxide (CO_2), Nitrogen (N_2), hydrogen (H_2), and hydrogen sulfide (H_2S) are formed in digestion. By volume CH_4 and CO_2 account for the majority of gas production. In a digester processing municipal sludge the CH_4 content should be between 60 and 70 percent and the CO_2 concentration should be between 30 and 35 percent. Increases in CO_2 and/or decreases in CH_4 could provide an indication that digestion has been inhibited. H_2S is also often monitored for odor control.